

THE EAST AFRICAN

AGRICULTURAL
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of

KENYA
TANGANYIKA
UGANDA AND
ZANZIBARWorld List abbreviation: *E. Afr. agric. J.**IN THIS ISSUE:*

THE REARING OF DAIRY CALVES

COMPARATIVE VALUES OF FODDER
PLANTS IN TANGANYIKALAND USE AND GRAIN YIELDS IN THE
KENYA HIGHLANDS

INDIGENOUS CLOVERS OF KENYA

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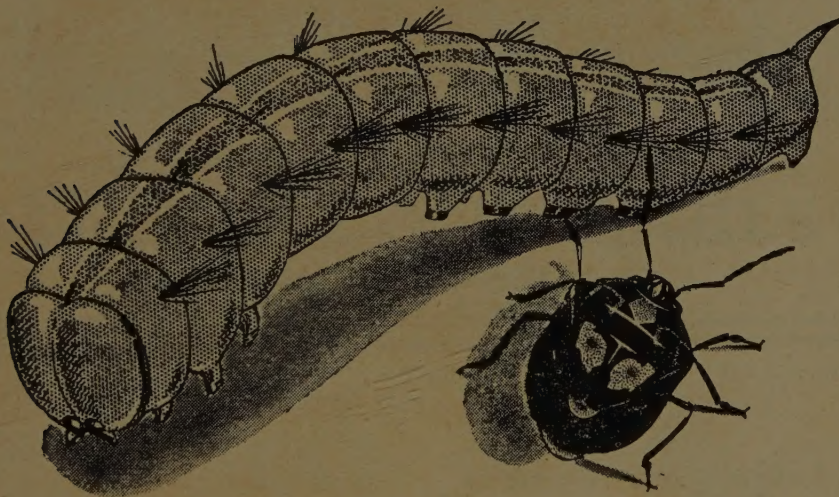
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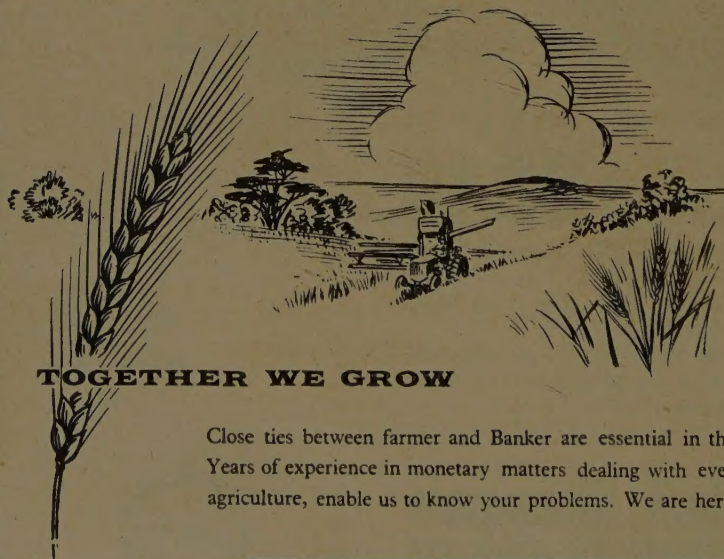
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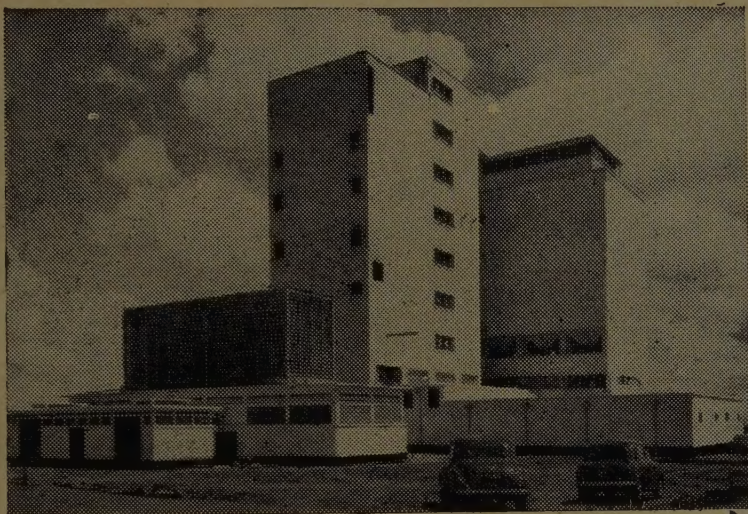
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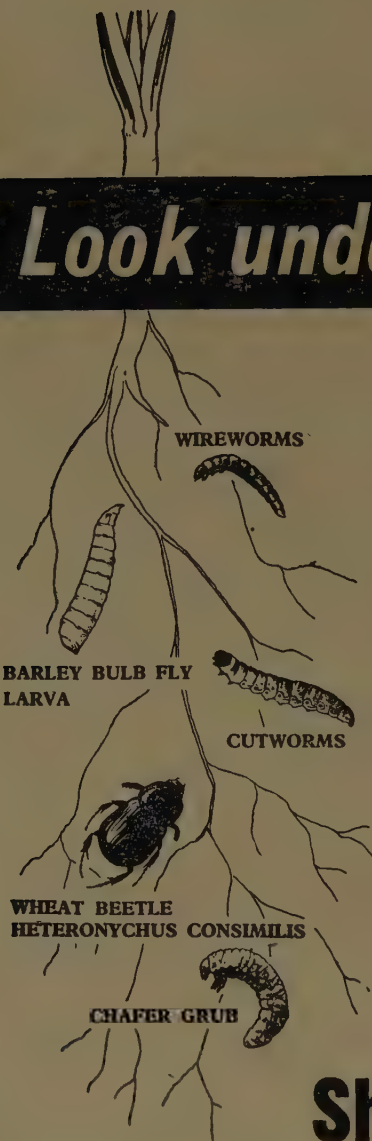
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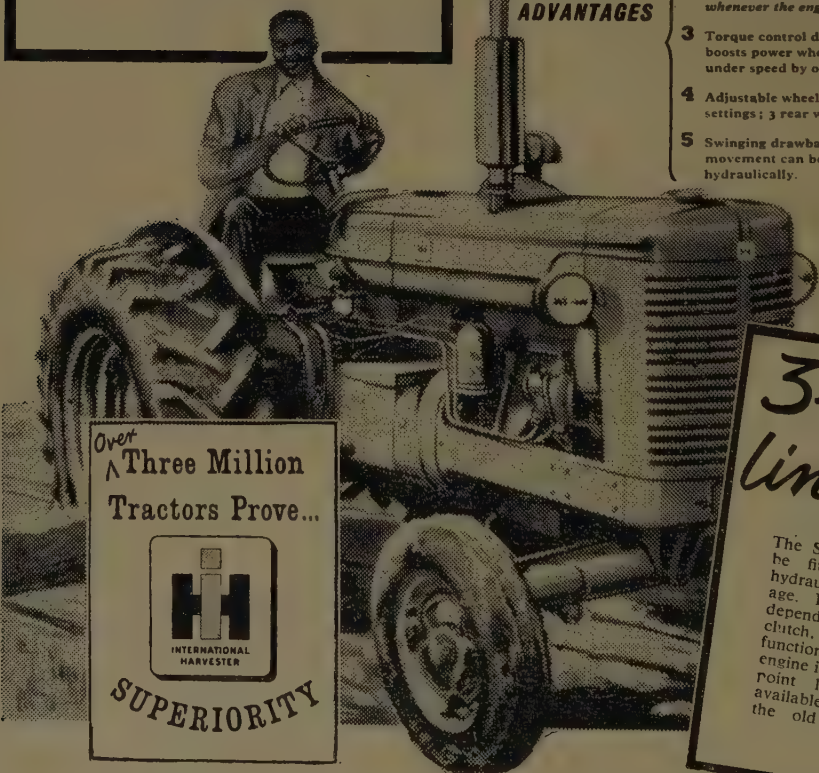
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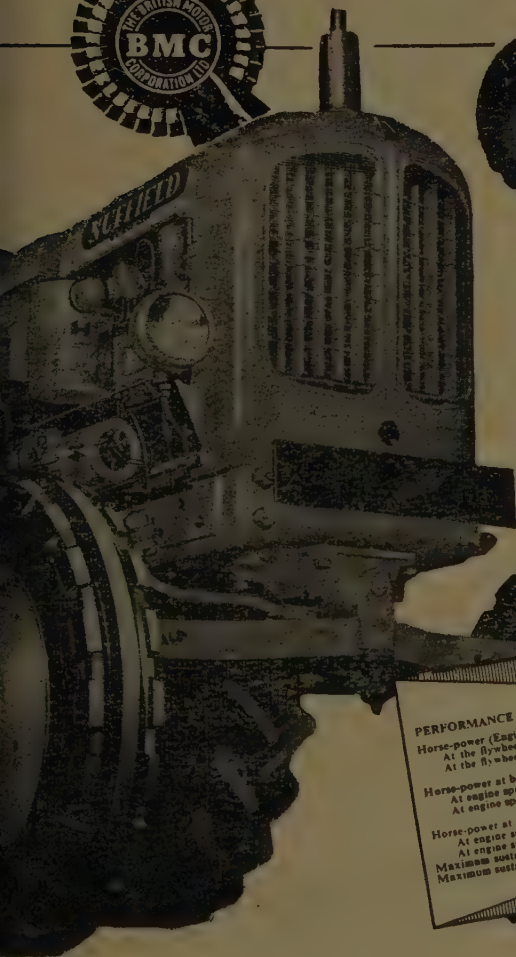
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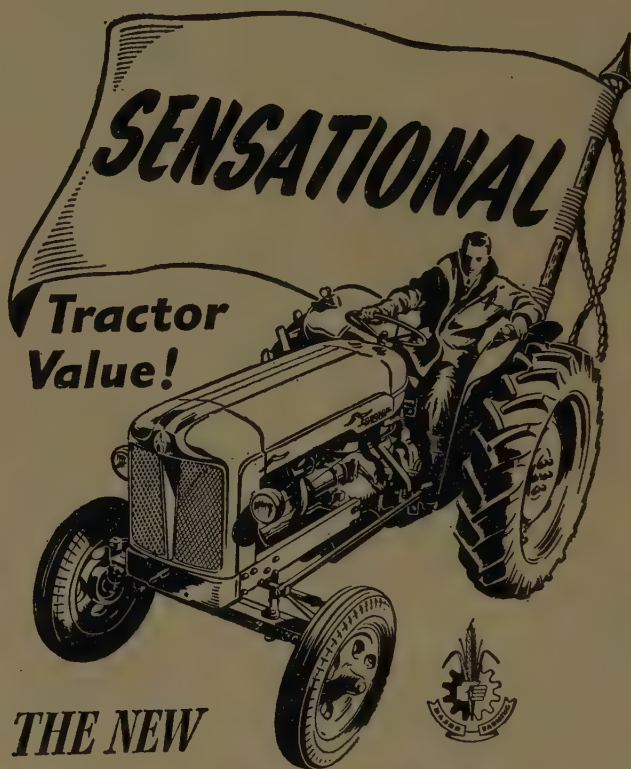


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The indigenous forests of East Africa, ranging from sea level to 10,000 feet, from tropical to temperate climates, and made up of a large number of tree species, maintain an enormous variety of insects, harmful, beneficial or of little importance; on the whole the forest probably suffers little from insects in its natural condition. Active forestry includes the establishment of pure plantations, a condition favourable to insects; where these plantations consist of exotics it is possible that indigenous insects may take to them with enthusiasm (so far, the outstanding case is *Oemida* attacking species of cypress) or that exotic insects may follow, as in the case of the Gonipterus weevil on *Eucalyptus* spp., both from Australia.

These notes are intended to give some idea of progress made since the writer was appointed as Forest Entomologist, first, in January 1950, to the Kenya Forest Department and later, from October 1951, to the East African Agriculture and Forestry Research Organisation, with a much wider sphere of action. To start with there was a practically clear field, rather embarrassingly clear in fact, since there was no reference collection of insects and very little recorded information. There were many insect pests requiring investigation.

A survey of East African forest insects was commenced at once; this has perforce been limited to qualitative studies, the minimum data being name of insect, name of tree affected, locality, date and at least some idea of economic importance. Information is recorded in ledger files (by insect families) and in a host-plant card index; so far, about 850 insect species are included, the greater proportion being Coleoptera. From this reconnaissance it is already possible to earmark species of known or of potential economic importance that need special attention and work on more quantitative lines.

For the essential identification work we have been almost entirely dependent on the very active co-operation of the Commonwealth Institute of Entomology. Since a very large proportion of our material is reared in the insectary from caged wood specimens (as

opposed to mere collection in the forest) it is perhaps not surprising that so many species (about 33 per cent) are "new to science"; this, combined with the fact that there is at present a serious shortage of taxonomic specialists, has led to a regrettable lag, which it is hoped will be rectified in future years. A particular point has been made of building up a collection of identified larvæ (which from the economic aspect, leads to rapid diagnosis) for study by specialists: our collection of Cerambycid larvæ has already been used by Mr. E. A. J. Duffy for his monograph on African members of the family.

Brief reference to a few of the insects of economic importance may now be made. Perhaps the most important is *Oemida gahani* Dist., a Cerambycid common as a dead-wood feeder in parts of Kenya and Tanganyika, which has taken to attacking living cypress trees without apparently affecting their health. The larva is still classified as a dead-wood feeder since it works in the heart of the tree, to which it gains access through external wounds, including pruning scars. It has also caused serious monetary loss to structural *Podocarpus* in Nairobi. A preliminary account of this appeared in 1953 (Gardner, Evans and Pudden, *E.A. agric. J.* 18: 176-183) and a further report will appear shortly. The gall on *Chlorophora excelsa* caused by the Psyllid *Phytolyma lata* Scott causes serious damage, especially to leaders of young trees, and will require full-time attention; plantations grown fully exposed to light are very liable to attack and there may be an answer in this observation. Termite attack in young plantations is another problem, especially in arid areas: the Silviculturist, Tanganyika, is experimenting here. Forest nursery problems (cutworms, cockchafers, weevils) are widespread but chemical treatment with B.H.C., Dieldrin (for example) seems adequate. Damage to freshly-felled logs by Ambrosia Beetles is widespread but has not yet been adequately assessed. In the first year or two requests for advice on control of Powder-post Beetles (Bostrichidae, Lyctidae) were very numerous but have now ceased, after a note was published explaining that if sapwood is to be used it should be chemically treated. Several pressure plants are now available in strategic places.

It is of interest that so far we have had no serious defoliation by Lepidoptera: this does not imply future security of course. The South African Saturniid, *Nudaurelia cytherea*, serious to *Pinus radiata*, has not appeared. Several epidemics on a small scale, at first alarming, were controlled by naturally occurring parasites or by virus or bacterial disease. A plantation of *Pinus radiata* suffered heavily in 1950 from a bagworm (*Acanthopsyche aethiops* Hamps.) but the insect duly disappeared with no serious after effects: no parasites were reared and it is probable that control was effected by the first instar larvæ being carried by the prevalent wind to an adjacent plantation of another species.

Shortage of staff continues to be acute. My own staff consists of four Africans, two of whom are beginners: Michael Kangeri has worked with me throughout; Vincent Omolo, originally sent to polish the floor, was detected registering curiosity with the aid of a lens and proved to have a flair for entomology, especially for work in the forest. The daily routine of setting, identifying, recording large numbers of insects and of checking numerous cages in the insectary is alone becoming overwhelming.

In 1952 the Uganda Forest Department deputed two Forest Rangers (Edward Kaye and Christopher Magola) who, after instruction, commenced work in Uganda on survey lines. Tanganyika followed suit and Elias Ndekarisho and Timothy Ndesamburo started similar work in Tanganyika. The work of these four officers has resulted in the collation of a great deal of basic information. The Kenya Forest Department, in 1952, deputed a Forester (J. O. Evans) to specialise on the field aspects of the Oemida problem; this officer resigned in March 1956, having, in spite of Emergency police duties, produced valuable information both on Oemida and for the survey generally. The same Department appointed its own Forest Entomologist (S. J. Curry) in 1953; he worked chiefly on Ambrosia Beetles until March 1956, when he took over the Oemida investigation.

On approaching the end of my last tour in East Africa I want to acknowledge not only the co-operation of the officers I have named above but that of the many forest officers who have provided information and have frequently gone out of their way to clear up certain points.

J. C. M. GARDNER.

THE REARING OF DAIRY CALVES*

By R. A. Ayre-Smith and R. P. Long,

Veterinary Experimental Station, Naivasha, Kenya

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Calf mortality is a serious cause of loss affecting the agricultural economy of many countries. A recent survey in Great Britain found the overall mortality of heifer calves up to six months of age to be 8.3 per cent [1]. Earlier workers in Britain recorded a higher figure and reported that every seventh pregnancy failed to produce a calf surviving after the first few months. From New Zealand, America and India come figures of from 7 per cent to 25 per cent losses. In the settled areas of Kenya the rate of mortality is considered to be approximately 15 per cent of the calves born alive. This loss would be considerably higher if based on the result of recorded pregnancies.

The financial significance of this high mortality is obvious. The disturbance caused to an organised breeding programme may outweigh the immediate financial loss to a progressive breeder. Losses from stunted and unthrifty calves aggravate the position. The first aim of calf rearing must be to reduce the death rate, then to ensure a vigorous and well-grown heifer.

CAUSES OF CALF MORTALITY

In highly developed and intensive dairying areas the ubiquitous micro-organism, *Bacterium coli*, is one of the more frequent causes of calf death, producing diseases known as White Scour, Joint Ill and Navel Ill. Yet many observers frequently fail to incriminate any single micro-organism and it is well known that functional disturbances may cause scouring. In Kenya lack of care and improper feeding are the usual factors contributing to this complaint, which is reported to be one of the commonest met.

Pneumonia, calf diphtheria and paratyphoid are some of the other diseases associated with a departure from sound husbandry. Special attention must be paid to the amount and temperature of the milk being fed, general hygiene and housing if these diseases are to be avoided.

Tick-borne diseases will cause deaths among calves, Heartwater, for example, being reported prevalent in the Nakuru area [2]. Anaplasmosis, Red Water and East Coast Fever will occur when infective ticks are present on calves. Tick control is the most obvious way to prevent these diseases. In certain parts of East Africa controversy has existed over the desirability of allowing calves to obtain immunity by remaining tick-ridden for their first six months of life. However, with grade dairy calves the risks attached to this method are great.

Calves should be sprayed or dipped after they have reached a month old, if there is any risk of tick infestation. Those who use dipping tanks should ensure that the young stock are dipped separately from mature animals in order to avoid injury and loss. As an alternative to these two methods calves may be reared in a tick-free environment, but care must be taken that infective ticks are not introduced on the bedding. "Vaccination" against Red Water and Anaplasmosis may also be used for calves.

Like tick-borne diseases, infestation with round-worms, tape-worms and flat-worms may be a serious problem in calves. Nevertheless, certain parts of the country are remarkably free from helminths and generally it is only in the higher rainfall areas that infestation is great. In these areas a diagnosis of the parasite causing the trouble should be obtained by submission of faeces samples to a veterinary laboratory and routine dosing with the appropriate anthelmintic adopted. Sound hygienic and husbandry measures will do much to lower the likelihood of infestation, and expensive drugs will not have to be given so often. While frequently the death of a calf is directly attributable to one of the more common calfhood complaints, it will be realised that the initial outbreak of a disease is usually caused by some departure from sound feeding and managerial practices. Infective organisms, by gaining strength and numbers in a sick animal, may then break down the resistance built up in stronger calves.

* This article is a revised version of *Notes on Animal Diseases*, No. XIII, originally published in this Journal in 1942, Volume 7, p. 178.

The further one departs from the natural system of rearing the greater the care that must be taken to ensure that all aspects of sound management receive attention. In Britain the conclusion of a recent survey with regard to the underlying causes of calf mortality was that faulty methods of husbandry were largely responsible. Furthermore, it was recorded that attempts to prevent the diseases of early calfhood by vaccination and their treatments by drugs and sera had not been very successful and had masked the need for a critical examination of management [3].

In Kenya, the underlying cause of mortality is most certainly faulty management. Unfortunately the factor of personal supervision is too often missing. Therefore, to help the calf withstand the hazards of unskilled management, it is essential to rear a vigorous and healthy calf able to resist the conditions it will encounter. This can best be done by careful feeding.

THE FEEDING OF CALVES

If a young calf possesses an optimum amount of energy, protective nutrients and bacterial antibodies, the organisms encountered in early life will not cause disease, unless the strains are particularly virulent due to passing through other diseased animals in which resistance has broken down. Antibodies are not present in the calf at birth and nothing can be done to influence the calf's bacterial immunity before it is born. Fortunately, by careful feeding of the dam before she gives birth, much can be done to ensure that the calf is born with adequate reserves of energy and protective nutrients, thereby possessing a good resistance to infection.

Preparation Before Birth.—A cow should be dried off six to eight weeks before calving in order that she may recuperate from her previous lactation and build up her body reserves for the following one. During this period a cow is usually "steamed up" or fed in anticipation of her subsequent yields. This practice not only benefits the cow but is of great value to the calf. Energy, minerals and vitamins, especially vitamin A, are of great importance to the calf at this stage, if it is to resist the hazards of unskilled management after birth. Good quality green grazing, or three to six pounds of a balanced dairy meal together with 10 to 20 pounds of silage or green succulent, should be allowed to a cow before she calves. A mineral mixture containing adequate supplies of phos-

phorus should also be available. As calving approaches, see that the cow's bowels are loose and do not allow the calf to be born in a dirty boma or cowshed.

Colostrum.—This udder secretion, which is also known as "beastings", is produced for approximately the first week of lactation and possesses special physical and chemical properties essential to the calf in early life. Its high content of vitamin A reinforces the reserves that the calf should already possess. Immune bodies are present in the non-fatty part of colostrum, and to these the calf's intestines are only permeable until shortly after its first feed. The calf can thus be given specific immunity against some of the diseases prevalent in the area in which it is born. Furthermore, colostrum possesses a high percentage of digestible nutrients which, although falling rapidly in the first 24 hours of lactation, act as an insurance for the production of a vigorous youngster. The physical properties of colostrum, which are related to its high globulin content, facilitate the expulsion of faeces and the formation of soft curds in the gut, thereby avoiding indigestion.

All calves should receive their dam's colostrum for the first three or four days of life. After this time its physical properties often resemble milk sufficiently for it to be incorporated with the herd output. If the dam's colostrum is not available, then that from another recently-calved cow should be given. At the worst, milk from another cow early in lactation may be fed. If the last practice is resorted to, half a teaspoon of castor oil per feed may be necessary for the expulsion of faeces and one ounce daily of cod liver oil should be allowed in order to build up reserves of vitamin A. The likelihood of hard curds forming in the gut can be reduced if half a pint of cooled boiled water is added to the milk. If cases of scouring do occur, all the milk should be replaced for two days by boiled water given at blood heat.

Whether to allow the calf to suckle its dam during the first few days of life, or to remove it completely and feed from a bucket, will depend upon the system of herd management. Yields of colostrum in excess of the calf's requirements may occur with high-yielding cows and overfeeding must be avoided. This is best done by allowing the calf only 20 minutes in which to suck two or three times daily. In this case it might be more advisable to remove the

calf completely 6 to 12 hours after birth, when it will have been licked dry by its dam. Alternatively, the calf may be removed from its dam immediately after birth and rubbed dry with a wisp of hay.

One pound of colostrum for every 8 to 10 pounds of the calf's weight must be fed from a bucket. This will entail providing four to six pints a day and feeding in two or three feeds (given at blood heat). These last two requirements are important to remember. A calf would naturally suck several times a day and, while obtaining milk slowly, the action of suckling would ensure thorough mixing with digestive juices and passage into the correct part of the stomach. Therefore, in bucket feeding, it is advisable to give the colostrum three times daily. The temperature at which it is fed must be between 95° F. and 100° F. Feeding excessively cold or hot milk will very soon cause scouring. In those herds where suckling of the colostrum is practised, the incidence of scours in early life is often reduced because of the avoidance of digestive disorders. At three or four days old the calves can be removed from their dams and taught to feed from a bucket. This may easily be done by withholding food for 12 hours after removal from the dam. Then, standing astride the calf's back, let it suck the fingers, and whilst doing this slowly lower the hand into the bucket of milk and withdraw the fingers. Two or three lessons in this way are all that are usually necessary.

Whole Milk.—The economy of food and labour is a most important consideration when planning the management of dairy calves. Milk is an essential food, but many methods have been proposed to rear calves on a minimum quantity. However, the ultimate value of the calf should be considered.

Calves have been successfully reared on 15 gallons of whole milk, being weaned at four weeks. Great attention is paid to hygiene measures and the calf must be persuaded to eat a high protein meal at an early age. It is necessary to continue to feed this meal up to six months of age or later and to give the calves grazing of a high standard until they reach a year old. Only the best quality hay is fed from a few weeks onwards. It is not considered advisable in Kenya to feed a limited quantity of milk in this way. The standards of hygiene and personal attention needed are great, and there are very few places possessing pastures of a sufficiently high standard to maintain a suc-

cession of calves gaining rapidly throughout the year. Also the climate is not reliably suitable.

The other extreme is bucket-feeding of milk for six or eight months, allowing the calf a total of 150 to 200 gallons. For a commercial farmer the economy of this method cannot be advised. Furthermore, overfeeding in early life is a most common cause of scours, and later it may undermine health and depress breeding qualities. This latter factor is not so apparent with male calves but overfed females may suffer from degenerate or even cystic ovaries.

When rearing calves on a limited amount of milk, the principal method usually followed is to give the calf a good start on whole milk for a period of 10 weeks and then to rely on a suitable intake of high protein calf meals, good quality hay and young pasture grass.

The feeding schedule given below is to act as a guide, but personal observation must be used to vary the amounts when necessary.

TABLE I—FEEDING SCHEDULE USING A LIMITED AMOUNT OF WHOLE MILK

Period in Days	Period in Weeks	Whole Milk per Day	No. of Feeds
1 ..	Colostrum Period	<i>pints</i> 4-6	3
2 ..		4-6	3
3 and 4		6-8	3
4-7 ..		8	3
8-14 ..	1st Week	8-10	2
15-21 ..	2nd "	10	2
22-28 ..	3rd "	10-12	2
29-35 ..	4th "	12	2
36-42 ..	5th "	10-12	2
43-49 ..	6th "	10	2
50-56 ..	7th "	8	2
57-63 ..	8th "	6	2
64-70 ..	9th "	4	1
	10th "		

Each calf receives 70-80 gallons of whole milk. An effort must be made to encourage the calves to eat good quality concentrates at an early age. Starting about the tenth day, a handful of whole oats, kibbled maize or some cake, if put into the bottom of the bucket towards the end of feeding, will also enable the calf to get a taste for these feeds and also prevent it adopting the unpleasant habit of ear sucking. When a month old, calves will eat about a pound of meal daily and by six months of age three to four pounds daily will be sufficient. The following rations are suitable and should be fed dry.

HIGH-PROTEIN MEALS FOR CALVES REARED ON
A LIMITED QUANTITY OF WHOLE MILK

Ration A				Per cent
Bran	..	..	..	25
Maize Meal	..	..	..	25
Oatmeal	..	..	..	25
Groundnut Cake Meal	..	..	..	10
Meat Meal	..	..	..	15

OR

Ration B				Per cent
Maize Meal or Oatmeal	..	..	..	40
Pollards	..	..	..	20
Linseed Meal	..	..	..	30*
Meat Meal	..	..	..	10

*Linseed meal must be boiled for ten minutes before being added to the mixture. Boiling prevents the occurrence of prussic acid poisoning.

OR

Ration C				Per cent
Oatmeal	..	..	..	45
Bean and Pea Meal	..	..	..	15
Bran	..	..	..	30
Groundnut Cake Meal	..	..	..	10

To every 100 lb. of these mixtures must be added 3 lb. of a mixture of:

By Weight			
Salt	..	..	1 part
Bonemeal	..	..	1 part
Feeding Chalk	..	..	1 part

Calves usually begin to chew the cud at three to five weeks old and good quality pasture hay or leafy lucerne hay should be available from this time onwards. An adequate supply of clean water is always necessary and the use of some compound proprietary mineral lick is often of benefit despite the inclusion of a mineral mixture in the meal.

Skim Milk.—On those farms selling cream, skim milk should be used as a valuable supplement to the previous method of rearing. A gallon of skim milk a day in two feeds will reduce the need to give such a high protein calf-concentrate. The changeover to skim milk must be made gradually during the eighth

week when two pints of skim should be mixed with eight pints of whole milk, four pints being added to six pints of whole milk in the ninth week and six pints of skim being added to four pints of whole milk in the tenth week. After that a gallon can be fed daily for a further three and a half months. If this amount is allowed the following concentrate rations will be suitable:

LOW-PROTEIN MEALS FOR CALVES REARED ON
WHOLE MILK AND SKIM MILK

Ration D.—Equal parts of Maize Meal and Sorghum Meal; or

Ration E.—Equal parts of Maize Meal and Oatmeal; or

Ration F.—Four parts of Maize Meal and one part of Bean Meal.

To each of the above mixtures 2 per cent of salt should be added. The requirements of these meals will be up to four pounds per calf daily. Similar remarks apply regarding hay, water and a proprietary mineral lick as with the limited whole milk method of rearing.

Economies can be made by introducing skim milk earlier than the eighth week. If this is done more personal supervision is required and a medium protein calf-meal should be allowed.

TABLE II—FEEDING SCHEDULE USING SKIM MILK

Period in Days	Period in Weeks	Whole Milk per Day	Skim Milk per Day	No. of Feeds
1 ..	Colostrals Period	pints 4-6	pints —	3
2 ..		4-6	—	3
3 and 4		6-8	—	3
4-7 ..	1st week	8	—	3
8-14 ..	2nd "	8-10	—	2
15-21 ..	3rd "	8	2	2
22-28 ..	4th "	6	4	2
29-35 ..	5th "	4	6	2
36-42 ..	6th "	2	8	2
43-49 ..	7th "	—	10	2
50-56 ..	8th "	—	12	2
57-140 ..	9th-20th "	—	12	2
141-147 ..	21st "	—	10	2
148-154 ..	22nd "	—	6	2
155-161 ..	23rd "	—	4	1
162-168 ..	24th "	—	4	1

The concentrate used may be similar to those previously mentioned under Rations D, E and F. Better results will be obtained with the following:

MEDIUM-PROTEIN MEALS FOR CALVES REARED
ON SKIM MILK*Ration G*

	<i>Per cent</i>
Maize Meal	75
Groundnut Cake Meal ..	25

OR

Ration H

	<i>Per cent</i>
Barley Meal	50
Oatmeal	20
Bran	10
Cottonseed Cake Meal ..	10*
Sim-sim Cake Meal ..	10

* Calves under four months of age may suffer from cottonseed cake poisoning if large quantities of the cake are allowed. The risk of this occurring is considerably reduced if good quality hay or pasture is available. In Kenya it is not advisable to give calves under four months of age a concentrate ration containing more than 15 per cent cottonseed cake.

A suitable mineral supplement to add to these meals is 3 per cent bonemeal and 1 per cent salt.

At first only a small quantity of these two meals will be eaten but encouragement must be given to calves to eat several pounds daily, so that by four or five months of age the calves are consuming four pounds a day together with a few pounds of hay. Ample supplies of fresh drinking water will still be necessary as will a mineral lick.

If supplies of skim milk are limited, it can be reduced by two pints per week from the ninth week onwards. In the thirteenth week calves will therefore receive two pints daily in one feed and will be weaned completely by the fourteenth week. When limited skim-milk feeding is adopted, it is necessary to allow a good quality hay, such as lucerne, and high protein meals such as Ration A, B or C.

Gruels.—In general the feeding of home-made gruels is not recommended except in an emergency. To be successful this method needs great attention to detail and more labour is involved than in dry feeding. However, gruels have one advantage over dry meals, namely that calves will usually eat meal as a gruel at an earlier age than if fed dry; but Australian experience indicates that the weight gains from this advantage are lost later in life.

Ration J is a suitable mixture for making into a gruel.

Ration J

Equal parts by weight of Linseed Meal, Blood Meal and Pollards.

Groundnut cake meal or soya bean meal can replace the linseed meal in this ration. All ingredients must be finely ground so as to remain in suspension. One part of this mixture is mixed with eight parts of water and brought to the boil. After cooling the gruel is fed at blood heat according to the schedule given below:

TABLE III—FEEDING SCHEDULE USING A GRUEL

Period in Days	Period in Weeks	Whole Milk per Day	Liquid Gruel per Day	No. of Feeds
		<i>pints</i>	<i>pints</i>	
1 ..	Colostrals Period	4-6	—	3
2 ..		4-6	—	3
3 and 4		6-8	—	3
4-7 ..		8	—	3
8-14 ..	1st week	8	1	2
15-21 ..	2nd "	8	2	2
22-28 ..	3rd "	6	6	2
29-35 ..	4th "	4	8	2
36-42 ..	5th "	2	10	2
43-49 ..	6th "	—	12	2
50-56 ..	7th "	—	14	2
57-140 ..	8th "	—	14	2
141-147 ..	9th-20th "	—	10	2
148-154 ..	21st "	—	6	2
155-161 ..	22nd "	—	4	1
162-168 ..	23rd "	—	4	1
	24th "	—		

Ration K

	<i>Per cent</i>
Pollards	70
Meat Meal	15
Soya Bean Meal	15

This gruel is recommended at the rate of $1\frac{1}{2}$ lb. daily, each $\frac{1}{4}$ lb. of meal being mixed with half a pint of skim milk to which is added a half-teaspoon of bonemeal and a quarter-teaspoon of salt.

Reliable proprietary calf meals are available and some can be fed as gruels. It is most important that the directions for using these meals be closely followed.

Foster Mothering.—On certain farms this may be an economical system to follow. When adopted skilfully, the method may give results that are usually most satisfactory, but it is not a rule of thumb method to practice and success will depend upon close observation of the cow and calves.

The yield of the cow should be anticipated and two or even three calves taught to suck

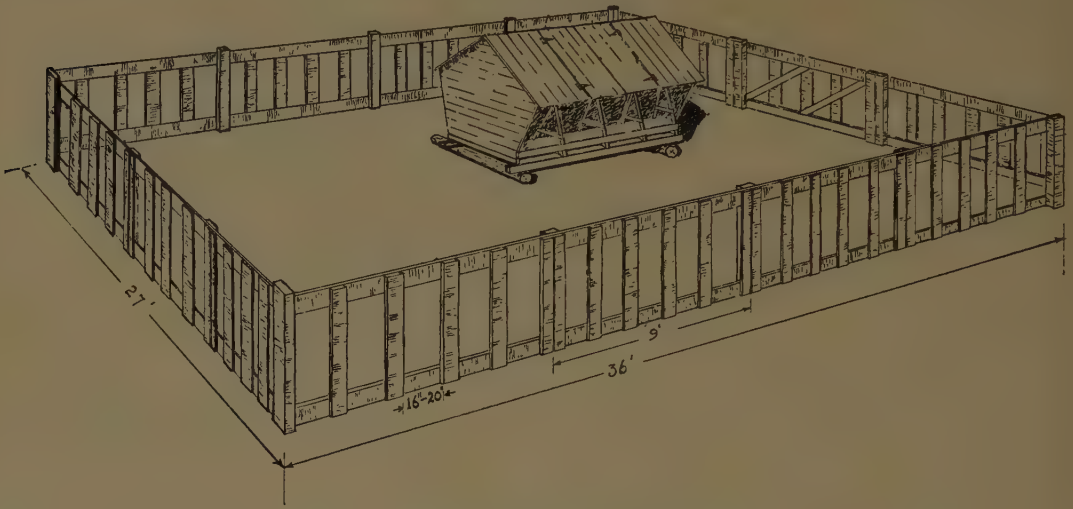


FIG. 1—CREEP-FEEDING PEN FOR CALVES

her. One calf may be her own, the others coming from high-producing cows that will have been sent to the milk herd. For a period of one or two weeks the cow may need to be yoked, preferably three times a day, and the strange calves encouraged to suck her at the same time as her own. When the cow shows no further restlessness at the introduction of the calves she may be turned out with the suckling herd.

The management of this herd needs to be watched. Foul night *bomas* must be avoided and shade and watering points should be easily accessible. Results will be most satisfactory if a system of creep feeding is adopted. By this is meant the practice of allowing calves access to some grain feed while they remain on pasture with their dams. In order to accomplish this extra feeding a suitable pen is necessary, located in the pasture near where the cattle usually rest or water. The pen is made to offer easy entrance for the calves but to bar the cows and older animals (Fig. 1). Any of the previous rations can be fed with advantage but coarsely ground oats or maize will be satisfactory.

If creep feeding is adopted it should be possible to wean calves at four to five months old and opportunity may then prevail of allowing the cow to suckle one further calf for the rest of her lactation.

Feed Supplements.—Results of the use of antibiotic supplements in milk or dry meal are conflicting. In Australia an indication was

found of little or no difference in growth rates between a control group and a group fed penicillin. Some American workers support this finding. Other workers using an all-vegetable protein starter-ration recorded that the addition of aureomycin appeared to stimulate appetite, thereby increasing growth rate. It appears, from a further study of work, that it is mainly aureomycin that is beneficial to calves. This antibiotic can be incorporated at the level of 1 per cent of a calf starter-meal or at the same level in milk. It should be introduced at four days of age and fed until the calf is 16 to 20 weeks old. Benefits from its introduction include a lower incidence and severity of scouring, increased weight gains and improved physical condition.

It is considered that the use of calf feeds containing antibiotics has application in an area with a highly-developed dairy industry. Their use does not reduce the need for sound husbandry.

HOUSING

Calves should be housed under conditions where they have a clean dry bed, reasonable provision for exercise and fresh air without draughts.

Permanent housing should include small individual pens for young calves (Fig. 2). In this way the calf cannot be readily infected by its associates and will not acquire the bad habit of ear sucking. An impervious well-drained

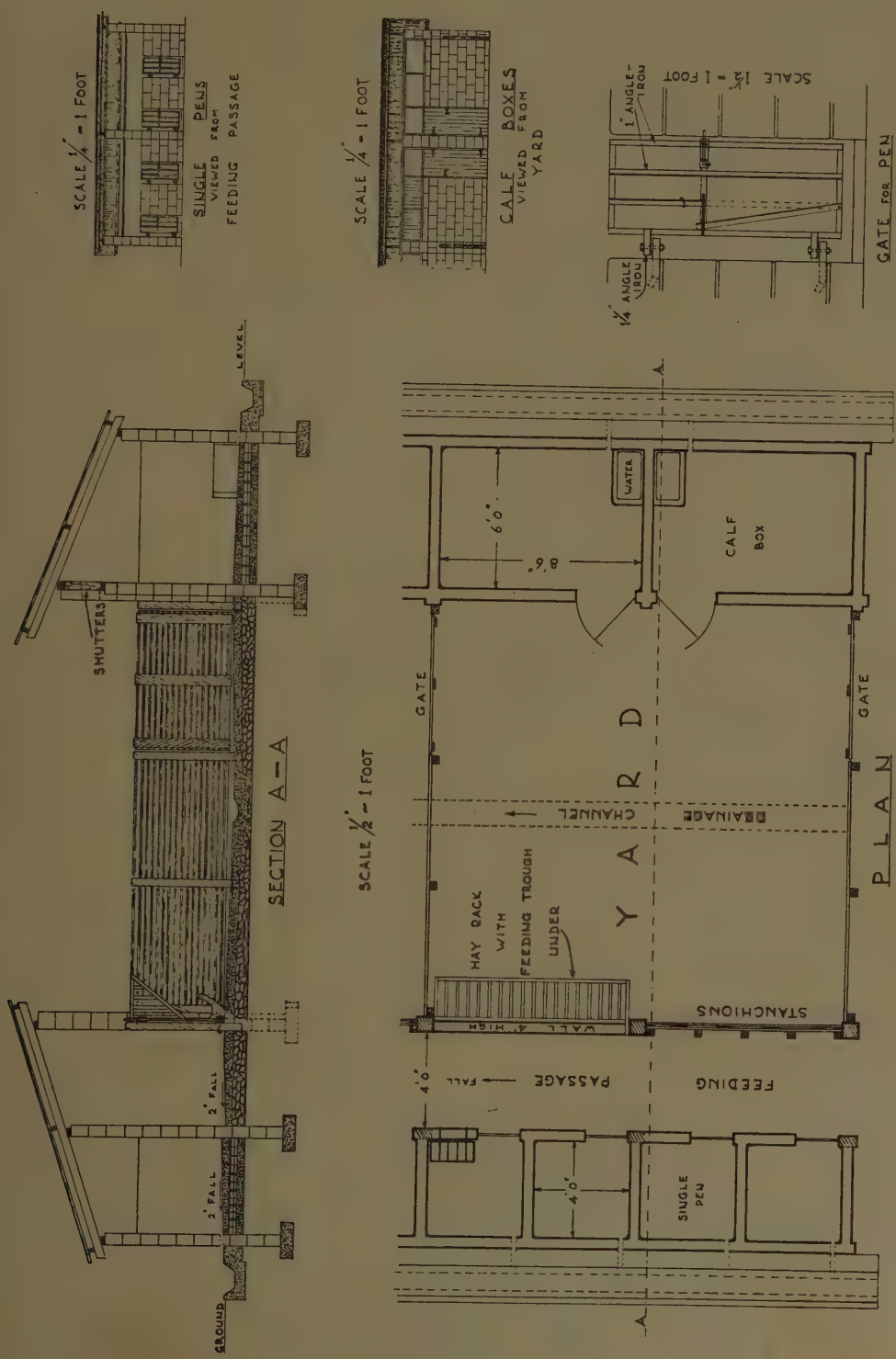


FIG. 2.—PERMANENT HOUSING FOR CALVES

floor is necessary, which should be kept adequately covered with dry, tick-free bedding. It is better to change the bedding every second or third day and in between these times to add clean bedding than, by changing daily, to allow the calf to lie on a cold, damp floor. A yoked gate will assist at feeding times, and the pen should also contain a box for meal and a small movable hay rack.

After one month calves can be moved to larger pens and housed together. Water must be available in this pen and a box for concentrates. At this age calves can be allowed out by day into shaded yards where hay or even silage may be fed. Water must be available, and the

yards drained in order to avoid their becoming foul. It is usually more convenient now to bucket-feed in the yards, and for this purpose stanchions should be provided to avoid bullying and waste of feed (Fig. 3).

From two or three months onwards calves can be allowed out to graze in the better paddocks; but it is advisable to provide shelter or to bring them into the yards during wet and cold weather. When bucket-feeding has ceased, it is as well to put them into the best paddocks and move them according to the grazing rotation. Calves of three or four months old and over can stay out day and night, but shade and shelter must be provided and meal-feeding continued.

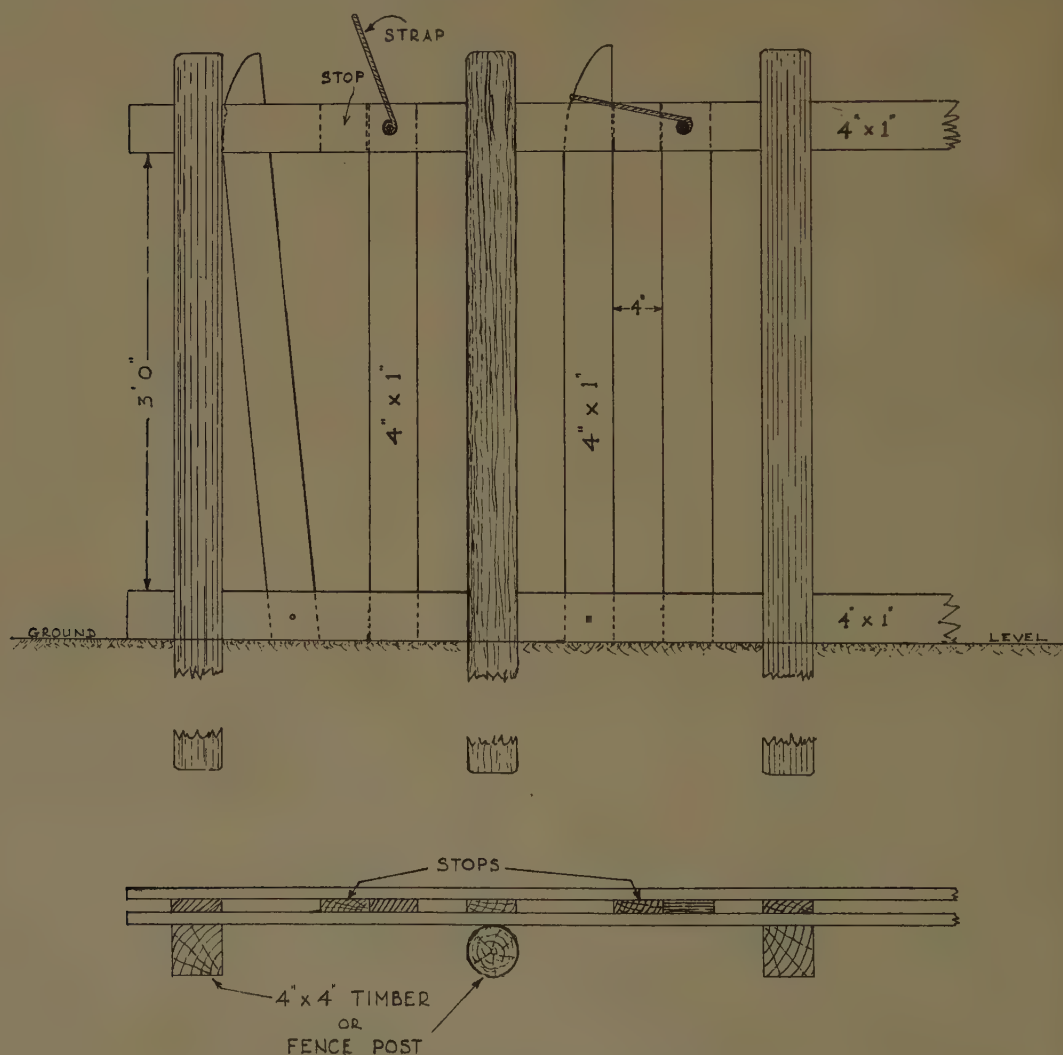


FIG. 3.—STANCHIONS FOR CALVES

The use of a permanent building may encourage the build up of disease micro-organisms, and strict attention has to be paid to hygiene if calves are housed in this way. On the other hand, by the use of movable pens a run of disease outbreaks can often be broken. The opportunity to move pens weekly on to clean ground will avoid infection. In them calves are often less subject to draughts and chilling; and the incidence of pneumonia has been found to decrease considerably when compared with the conventional type of permanent building.

This Department considers such movable calf pens as probably the most suitable and practical calf housing.

When constructing these pens it is important to ensure that adequate roof insulation is provided (Fig. 4). Cases of distress and disease

have been recorded through calves lying too close to unshaded corrugated iron. This is more likely to occur if bedding is allowed to accumulate.

Movable pens should not be used on over-grazed paddocks, otherwise risk of infection will be great. Nor must the area be badly drained. In wet weather bedding should be provided, but floors are unnecessary except in some of the higher rainfall areas.

HYGIENE

When the cow is to calve down in a loose box, the box should be thoroughly cleaned before use and plenty of fresh bedding provided. In Kenya it is more common for cows to calve in paddocks. If the calf is to be removed at birth, it should be briskly rubbed down with a wisp of dry bedding and put into

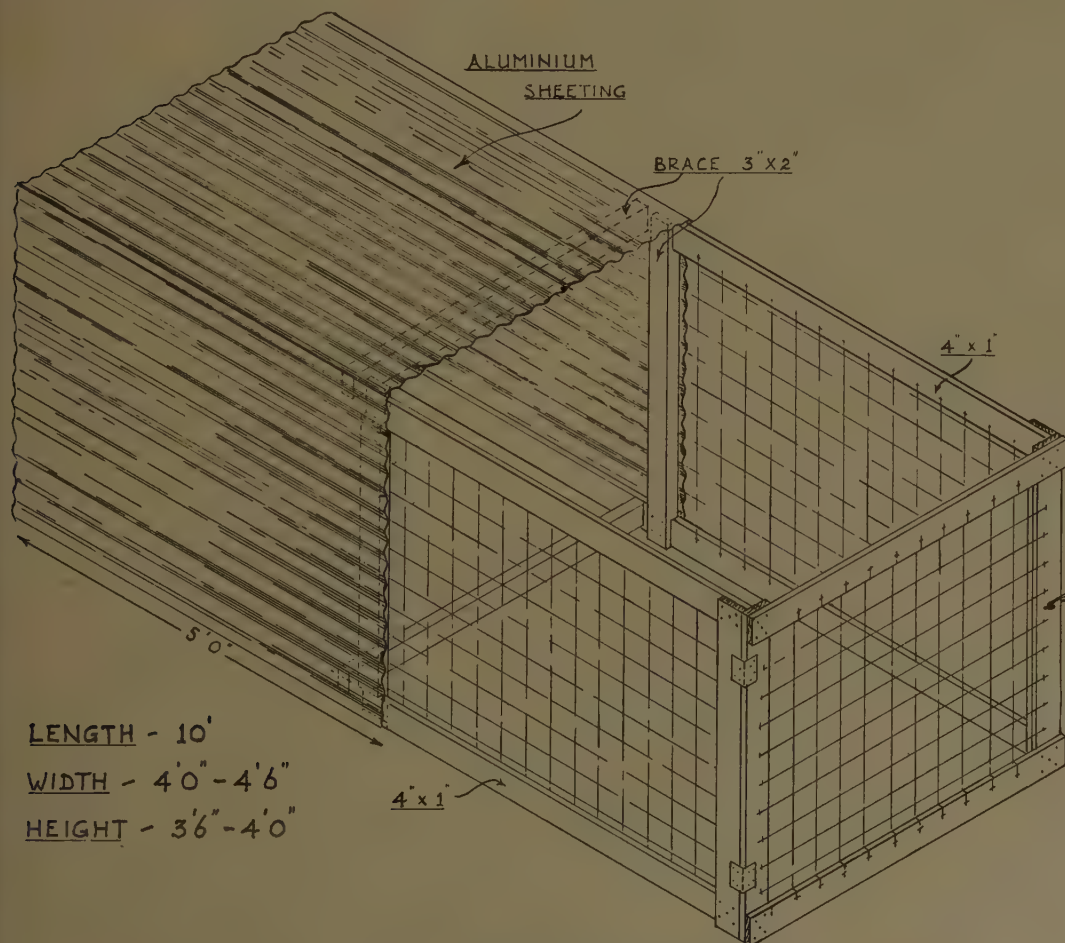


FIG. 4.—MOVABLE CALF PEN.

a clean pen. In many areas it is necessary to apply iodine to the navel. This may have to be done daily until the cord is dry. In this way the risk of a sudden invasion of infective organisms will be reduced.

Prior to putting a calf in one pen of a permanent building the pen should be thoroughly cleaned. It is not sufficient to apply whitewash; the walls and floors must be scrubbed with some coal-tar preparation or caustic solution. The importance of this measure is only appreciated by stockowners whose calves have suffered from an infectious disease. Dry bedding must be provided and cleaned out at least twice weekly, but fresh bedding should be added daily. If disease occurs, the bedding must be renewed daily and disposed of in such a way that calves or older stock do not have access to it.

All buckets for feeding calves must be kept scrupulously clean and sterilised in a similar way to the dairy utensils. Healthy animals must never be fed from the same bucket as a diseased one, unless the bucket has been steam or chemically sterilised. Regularity of feeding and only allowing whole or skim milk at a temperature of 95° F. to 100° F. are two other factors recognised for successful results. Rapid changes in the use of feeds must be avoided.

MANAGEMENT

Dehorning.—Dehorned cows are more docile, easier to handle and usually return better profits. Dehorning is simple and various ways exist for doing it. When the calf is four or five days old the horn "buttons" can easily be felt. The hair round these buttons should be cut short and each button rubbed with a moistened caustic potash stick until nearly bleeding. For a few days after this the calf must be kept out of the rain to avoid any caustic being washed into the eyes. Naturally reared calves may burn the flanks of their dams when suckling; it is best, therefore, to use an alternative method under this system of rearing. The buds can be burnt off by using a hot iron. This is done by ringing the bud with the hollowed-out end of an iron made for this purpose and then burning the elevated separated portion immediately afterwards with the other solid end of the iron. Dehorners, not unlike bolt cutters, are also obtainable for use on more developed horns.

Nipple Feeding of Calves.—The use of a special type of bucket, incorporating a rubber

teat, has been found successful by some farmers. When the calf is allowed to suck from the teat, the milk passes slowly into the true stomach and gradually mixes with gastric juices as in natural suckling. The use of this method is reported to have reduced the incidence of scouring. Ear sucking is also avoided.

These advantages may be offset by the greater expenditure of labour and time required to sterilise the nipples, tubes and valves. If sterilisation is not effective, there will be a predisposition to scouring due to a build-up of organisms in the dirty apparatus. The use of these buckets is only recommended on farms where adequate supervision is available, and where cases of scouring have failed to respond to the correction of other aspects of management.

Development of the Fore-stomachs.—While a mature cow can readily digest fibrous feeds, calves at birth cannot do so, due to the undeveloped state of the fore-stomachs. The necessity of encouraging early development of these stomachs is most apparent with calves reared on limited quantities of milk. Only in this way can the micro-organisms inhabiting the stomachs convert the nutrients of hay and meal for use by the calf. Feeding best quality hay made from young grass or lucerne will promote the rapid development of the micro-organisms responsible for food conversion, and in this way the calf can make full use of the supplementary feeds available. This will explain why some farmers practising a limited milk system of rearing obtain heifers at nine months of age in equally good condition as those reared on larger quantities of milk.

Introduction of a cow's cud or ruminal contents to the diet of a young calf will also assist in establishing the micro-organisms responsible for food synthesis. Proprietary preparations are available for this purpose, but under normal farm conditions their use is not considered necessary.

Grinding Grain and the Use of Silage.—Except when grain is fed as a gruel there is no benefit in grinding it finely. Coarse grinding may be needed for the hard grains of barley, wheat and sorghums and for other grains to ensure adequate mixing. Nevertheless it may be of benefit to feed maize and oats unground as the calf will chew these grains, resulting in their slower ingestion and more thorough mixing with digestive juices.

Silage may be fed to calves from two months onwards. It is important to assess its quality. If good legume hay is available there is no advantage in feeding silage, but in the absence of good hay the addition of a few pounds of high-protein silage will be beneficial. Care must be taken to avoid decomposition of uneaten silage giving rise to digestive disorders through contamination of other feedstuffs.

Rotation of Pastures.—The success of feeding limited quantities of milk depends upon feeding adequate quantities of a high-protein calf meal and the use of properly rotated pastures. Whatever the system of rearing, only the best paddocks must be used for calves.

Often it is only possible to use those paddocks around the farm buildings in which to graze calves. If this is the case, it is important to reserve some of these paddocks especially for calves and not to use them for sick animals, calving cows or work oxen. It is also most important to rest the paddock periodically and thereby reduce the worm population.

As soon as the calves can be left out day and night they should fit into the rotation of paddocks ahead of the dairy herd. Ideally they should graze a paddock midway between successive cow grazing. When there is only one milk herd it may be possible to graze the young heifers in the paddock into which the milk herd is next to move. Under the bail system of milking it might be arranged that this paddock was adjacent to that in which the milk herd was grazing. Any supplementary lucerne, silage or hay allowed to the milk herd could then be taken easily to the heifers at the same time as it was brought to the cows. Steers or dry cows should be used to finish the rough pullings left by the milk herd. In this way one paddock would be grazed for three periods of possibly two weeks, firstly by young heifers, then by the milk herd and finally by the dry herd or steers.

Care of the Young Heifer.—The need to continue the care spent on the calf has already been mentioned. If good quality rotated pastures are available they will be sufficient except in cases where only a limited quantity of milk has been allowed. If this is the case, a few pounds daily of calf meal should be fed for several months.

During dry periods supplemental feeding of young heifers is most essential. Ten pounds of lucerne daily together with one or two pounds of grain will keep the heifers growing well. If only silage or grass are available then half the grain should be replaced by cake.

Finally, when weaning calves off their dams or foster mothers at four to six months of age, remember to ensure that the weaning paddocks have an adequate source of fresh water and that the best quality feed is available.

Vaccination.—If calf diseases are not apparent on a farm the need to vaccinate may be small. Vaccination is, however, an added means of ensuring the calf's resistance. The Veterinary Laboratories at Kabete produce several vaccines and the possibility of their use should be discussed with the local veterinarian or livestock officer. It must be realised that the use of vaccines does not reduce the necessity for care and good feeding.

Veal Production.—It is becoming increasingly important for dairy farmers to exploit all sources of revenue. Consideration should be given to producing veal from male calves of the larger dairy breeds. Liberal feeding with whole milk for five to eight weeks should result in a product most acceptable to the butchers.

Veal production does require skill. Calves should not be allowed to over-exercise; and they need from one to two gallons of whole milk daily divided into three or four meals. Some idea of the economy of this method can be obtained by reckoning that one gallon of whole milk is required on the average to produce one pound of liveweight increase. Separated milk fed together with a proprietary milk substitute can be successful provided calves are kept gaining rapidly.

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COMPARATIVE VALUES OF FODDER PLANTS IN TANGANYIKA

By H. J. van Rensburg, Veterinary Department, Mpwapwa, Tanganyika

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Data embodied in this article were obtained from tests and observations carried out at Mpwapwa in Central Tanganyika and elsewhere in the territory. The altitude at Mpwapwa is 3,500 ft. above sea level and the average annual rainfall about 26 in. Most of the rain falls between December and April while the rest of the year is generally dry. The soil along the fan slopes consists of red sandy loam while along valley bottoms it is generally darker in colour and heavier in texture. The natural vegetation consists of deciduous thicket, which apparently is the climax formation and is composed of many genera and numerous species. It includes genera such as *Acacia*, *Cassia*, *Grewia*, *Commiphora*, *Lannea* and many others. The bush thicket prevents grass growth due to competition for light and moisture, but grass grows in open glades and readily spreads to cultivated fields newly cleared from bush.

At altitudes above 4,000 ft. fairly open *Brachystegia* woodland with interspersed grass growth is common.

FODDER GRASSES AND LUCERNE

A field one acre in extent that was planted to lucerne about 1937 was replanted to *Setaria splendida* and *Setaria sphacelata* in 1949. Both these grasses grew well and produced excellent yields under irrigation with manuring. It was then decided to compare yields and fodder values of four species, and at the end of 1951 800 square yards were planted to each of these while the rest of the plot was used for further testing and selection work. The four species selected were:

Pennisetum purpureum (Elephant grass).

Setaria splendida.

Setaria sphacelata.

Medicago sativa (Provence lucerne).

The plants from all the plots were cut periodically and weighed. Comparative yields are given in Table II and the following observations were made:

Pennisetum purpureum (Elephant grass)

The Elephant grass used is a relatively glabrous variety obtained from Kawanda,

Uganda, in 1946. This variety is easily handled and therefore preferable to hairy kinds even though it may be somewhat lower yielding. It was noticed that some seedlings of this variety were very hairy, some only slightly hairy and other glabrous. It has not yet, however, been determined whether glabrous plants derived from seed will breed true by selection. Elephant grass can be propagated without difficulty from cuttings and the retention of this glabrous variety is therefore comparatively easy. The growth rate is most rapid between October and June but slows down considerably with the onset of the cool season. Between July and September the growth rate is slow and even with regular irrigation the plants are almost dormant. The grasses were cut about six times each year and lucerne about eight times. Fodder yields from Elephant grass exceed those from all other species, and on the irrigation plots an average yield of 103 tons per acre per annum was obtained over a period of four years. This is much higher than the yield of lucerne, which averaged 37½ tons per acre per annum for the same period. The protein content of lucerne, however, is over 20 per cent compared with about 10 per cent for the grasses at their optimum growth stage; in spite of this difference the grasses have proved to be of excellent fodder value both green and as silage. They can either be ensiled by themselves or mixed with lucerne, velvet beans, cow-peas or other legumes.

The feeding value of very young grass is comparable to that of lucerne, but, as the plants mature, their value decreases until it reaches the stage when it is of very little food value. The utilisation of Elephant grass and other species at the optimum stage of development is therefore a most important factor and one that is unfortunately very often neglected. The quality of fodder depends to a much larger extent upon the way in which it is used than on the species and there is much more variation within one species during different stages of growth than amongst different species at a comparable stage of development. Table I gives the relative value of Elephant grass and other species analysed on a dry-matter basis at different stages of growth.

TABLE I

	Crude Protein	Ether Extract	Crude Fibre	Nitrogen free Extract	Ash
ELEPHANT GRASS					
Very young elephant grass 1 foot high ..	20.2	3.6	27.4	28.7	20.1
Young Elephant grass 4 feet high suitable for silage ..	11.2	2.9	33.4	38.2	14.3
Elephant grass in advanced stage about 8 feet high ..	5.9	2.1	35.4	42.3	14.3
Tall Elephant grass with hard stems 11 feet high ..	2.5	1.6	37.7	39.3	18.3
<i>Setaria sphacelata</i>					
Very young <i>Setaria sphacelata</i> 1 foot high ..	21.3	3.8	26.4	32.3	16.2
Young <i>Setaria sphacelata</i> 2 feet high ..	15.3	2.9	35.2	32.0	14.6
<i>Setaria sphacelata</i> . Flowering stage 4 feet high ..	8.7	2.8	42.0	36.1	10.4
Old <i>Setaria sphacelata</i> . After seeding and 6 feet high ..	4.1	1.3	36.3	50.5	7.8
SILAGE MIXTURE					
Mixed silage of lucerne, Elephant grass and <i>Setaria</i> ..	8.1	4.6	38.5	31.9	16.9
MAIZE					
Maize at "milky" stage ready for silage making ..	5.0	1.2	28.7	58.0	7.1
LUCERNE					
Lucerne at early flowering stage ..	21.6	2.1	34.3	31.6	10.4
COWPEAS					
Cowpeas at flowering stage ..	27.5	3.9	17.7	38.2	12.7
<i>Glycine javanica</i>					
Young pre-flowering stage ..	17.9	2.3	30.3	40.7	8.8
RUSSIAN COMFREY					
Young pre-flowering stage ..	19.0	2.9	14.0	33.7	30.4
<i>Setaria splendida</i>					
Medium-young stage 4 feet high and suitable for silage ..	11.3	3.5	39.2	30.7	15.3

On small preliminary test plots under irrigation closely-planted Elephant grass was consistently higher yielding than more widely spaced plants and produced an average of 85 tons fodder per acre over three years, compared with 60 tons from those which were more widely spaced (i.e. half the plant population per acre).

Elephant grass planted under dry-land conditions survived reasonably well during three successive unfavourable years with low rain-

fall and produced a considerable amount of fodder throughout this period. In parts where it was planted in eroded gullies, yields of up to 68 tons green fodder per acre were obtained compared with about 18 tons per acre on adjacent flat land. The average yield for a period of three years under these conditions was 34 tons per acre. Yields of *Brachiaria brizantha*, *Chloris gayana*, *Cynodon plectostachyum*, *Panicum maximum* and *Setaria sphacelata* under dry-land conditions range between 20 and 30 tons per acre of green fodder, and it seems that during years of more favourable rainfall considerably higher yields might be obtained.

On the Iheme Stock Farm, south of Iringa in the Southern Highlands Province, in damp valley soil of granitic origin and sandy in nature, Elephant grass planted on ridges and treated with manure yielded about 50 tons of valuable green fodder per acre and dry-season yields were quite large. On a comparative basis it out-yielded Kale six times and turnips 11 times.

On these granite soils, lucerne gave rather small yields, while sweet potato tops and tubers produced very satisfactory crops of fodder. Grasses such as *Chloris gayana*, *Cynodon plectostachyum*, *Setaria sphacelata* and *Setaria splendida* also produced very satisfactory results under these conditions.

Elephant grass wisely used is a very suitable fodder and can be grown satisfactorily in most parts of Tanganyika, provided that suitable places are selected for its establishment. It grows best in high rainfall areas or along drainage lines where soil and moisture conditions are favourable, or under irrigation. On properly cultivated soil it grows in areas of relatively low rainfall, producing fairly good yields of fodder and it has a wide altitude range varying from sea level to over 6,000 ft.

Kennan [1] states that at Matopos in Southern Rhodesia, yields of Elephant grass of 32 tons of green material per acre under dry-land conditions, and upward of 50 tons per acre under irrigation, have been obtained, while in areas where growth is not limited by cold weather and winter frosts, yields can exceed 100 tons per acre. He also mentions that under dry-land conditions rows are best spaced at least 12 ft. apart and plants 3 ft. apart in the row where the crop is to be maintained for a period of years.

Setaria splendida

Setaria splendida is a most productive, leafy, succulent, fodder grass that is capable of yielding approximately as much fodder as Elephant grass. The plants grow about 6 ft. high with a heavy growth of wide, smooth, drooping leaves. It requires favourable conditions, however, and could not be successfully propagated on poor soil or without adequate moisture. Being such a leafy, soft-stemmed and entirely glabrous plant it is very easily handled and most suitable for green fodder and silage. Under favourable climatic and moisture conditions it thrives from the coast to altitudes of 8,000 ft.

I believe the variety of *Setaria splendida* in question originates from Nyasaland. Planting material for establishment at Mpwapwa was obtained from Kawanda in Uganda in 1946 and "bulking up" from side shoots was found to be relatively quick and easy. Under irrigation and with manuring at Mpwapwa it produced an average of 97 tons green fodder per acre per annum over a period of four years.

It also grows very well in parts of the highland areas of Southern Tanganyika and on the slopes of the volcanic mountain blocks in the Northern Province. In these parts, where people sometimes complain of the marginal effects of Elephant grass on their coffee and other crops, *Setaria splendida* might be more suitable as it does not develop such a vigorous root spread. Like Elephant grass, though not to quite such a marked degree, the growth rate slows down between July and September.

Growth is generally very rapid after cutting and on fertile soil with adequate moisture it can be cut six to eight times per year.

Setaria splendida is difficult to grow from seed, and the only plants so far established from seed at Mpwapwa were germinated on blotting paper in petri dishes and transplanted in seed tins. It is, however, fairly easy to propagate plants vegetatively, and, in view of the excellent yields of fodder that it is likely to produce, establishment from roots is quite feasible.

Chemical analysis also reflects the excellent quality of *Setaria splendida* as a fodder, though like Elephant grass and other species it deteriorates in quality with maturing and the optimum stage for use seems to be when the plants are about 4 ft. high.

Setaria sphacelata

Setaria sphacelata is less productive than Elephant grass and *Setaria splendida*, but it has the advantage that it can be established from seed. It grows about 6 ft. high and is suitable for silage, hay and grazing. This species is very widespread and numerous different forms and varieties occur throughout southern and eastern Africa. Apart from a few local varieties, those tested at Mpwapwa were obtained from South Africa and originally came from Bechuanaland. A very noticeable feature was the large number of varieties or growth forms selected from the original small sample of seed. Some of these have a rather flat, spreading growth habit, while others are tussocky and vary greatly in general succulence and leaf development. Some forms are extremely leafy but are slow in producing flowering culms, whereas others have very few leaves and are straggly with notably quick development of culms and seed heads. Like a number of other pasture plants, the leafier and more attractive types are shy seed producers and do not stand up well to adverse climatic conditions.

In comparative yield trials under irrigation with manuring, *Setaria sphacelata* produced an average of 63 tons green fodder per acre over four years and was therefore considerably less productive than the species described above.

Selections made and established in a series of small plots show a great variation in growth and yield. Some of these were very leafy and upright, others somewhat spreading and flat at the base with reddish stem markings. The different varieties also show great variation in seeding, the length of time in which seed culms and heads are produced, and in the actual number of seed heads formed. Six plants of each variety were established in small plots one yard wide and six yards long. Five of these plots yielded a total of 4,945 lb. of green fodder over a period of three years, which amounts to an average of 165 lb. per plant per annum. Another variety yielded an average of 254 lb. from six plants per plot compared with 591 lb. from a plot of equivalent size where 18 plants were spaced closely in two rows. These latter figures were obtained from small plots and might therefore not be quite typical of results that can be achieved on field scale, but they do give an indication of the potential productiveness of some of these grasses under special treatment.

On field scale without irrigation, *Setaria sphacelata* established at Mpwapwa could not survive the drought years experienced in Central Tanganyika between 1953 and 1955. Practically all the plants died out except for a few along some of the drainage lines.

On the Iheme Stock Farm in southern Tanganyika, at 6,000 ft. altitude and with higher rainfall, however, *Setaria sphacelata* plants continued to thrive over a period of years, particularly near the drainage lines, and seedlings established themselves in adjacent natural grassland. It also thrives in other parts of the Highlands as well as in western Tanganyika and in the mountain areas of the Northern Province where soil and moisture conditions are favourable.

Medicago sativa (lucerne)

Lucerne grows very well at Mpwapwa, and various other parts of Central and Northern Tanganyika are favourable for the production of this fodder plant. The yields obtainable from lucerne, however, do not compare favourably with those from fodder grasses such as Elephant grass and *Setaria splendida*.

A very important point in favour of lucerne is its vigorous growth during the cool season, from about July to September, when the grasses are more or less dormant. During this period two to three extra cuttings, with considerably increased yields compared with the grasses, might be obtained from lucerne. Furthermore, although there is likely to be an appreciable increase in fibre content with enhanced growth, the protein content of lucerne does not decrease as rapidly as it does in the grasses on maturity.

There is probably room for production of some lucerne as well as high-yielding fodder grasses on many farms; and the merits of each will have to be weighed up as circumstances arise.

In several parts of Tanganyika lucerne does not thrive, whereas Elephant grass and other fodder species grow very well. Under these circumstances it would be best to concentrate on the grasses, because with intensive use they are capable of producing a considerable bulk of good-quality foods, even on some of the poor soils of Western Tanganyika. The average yield of lucerne from the irrigation field over the four-year period was 37½ tons per acre per annum or slightly more than one-third of the yield of Elephant grass and *Setaria splendida*. This is a very important factor in planning the

ratio of lucerne to other fodder plants to be grown.

The average annual yield in tons per acre over a period of four years of lucerne and each of the three grasses described are given in Table II for comparison.

TABLE II

	YIELD IN TONS/ACRE				Average for four years
	1952	1953	1954	1955	
<i>Pennisetum purpureum</i> (Elephant grass) ..	102	81	133	95	103
<i>Setaria splendida</i> ..	97	72	123	96	97
<i>Setaria sphacelata</i> ..	65	47	81	58	63
<i>Medicago sativa</i> (Pro- vence lucerne) ..	45	35	46	24	37½

Shortage of water was experienced at times so that there was insufficient for regular irrigation, and the marked decrease in yields during 1953 and 1955 was probably largely due to drought conditions during these years.

Other Suitable Pasture and Fodder Plants

Several other grasses have given satisfactory and encouraging results although they seem to be more suitable for growing under dry-land conditions, but some species, for example *Brachiaria brizantha*, requires a rainfall slightly higher than that normally experienced in most parts of Central Tanganyika.

On small plots of 40 square yards each, under irrigation, the average annual yields per acre over a period of four years were as follows:

	Tons per acre
<i>Brachiaria brizantha</i>	57
<i>Cenchrus ciliaris</i>	42
<i>Chloris gayana</i>	36
<i>Dicanthium papillosum</i> (aver- age for three years)	38

These grasses, and other species such as *Panicum maximum* and *Cynodon plectostachyum*, yield from 25 to 30 tons of green fodder per acre under ordinary field conditions. This would be equivalent to about 3½ to 4½ tons dry matter per acre, while more intensive soil treatment and closer management would result in considerably increased yields. These grasses are all excellent for grazing or hay and can be used for silage-making, although it is preferable to use the heavier-yielding,

more bulky species such as Elephant grass and *Setaria splendida*, or annual crops such as maize and sorghum with velvet bean and cow-peas.

One of the difficulties experienced with silage making is the development of very high temperatures due to inadequate compaction. In practice it seems that this can be best overcome by cutting the plants at a relatively young and succulent stage, by rapid filling and by special measures to get the material thoroughly compacted so that as much air as possible can rapidly be excluded. A reasonably large trench silo about 14 ft. wide would also facilitate close packing, especially if a tractor or lorry could be run over it at frequent intervals during filling. Chaffing the plants would also help considerably, but this measure might only be possible or practicable in very few instances.

Major advantages of silage making are twofold:

- (a) It entails the conservation from surplus growth of a valuable supply of succulent fodder for the dry season when supplementary food is most urgently required.
- (b) By cutting the plants for silage about the middle of the rainy season a second growth of young succulent fodder is made possible. If herbage from the early growth is not grazed or cut and removed, it results in an accumulation of coarse fibrous material most of which has deteriorated in feeding value or has been trampled down and spoilt by the cattle. Furthermore, it also prevents young fresh growth for use later in the season.

From four small trench silos with a total capacity of 59 tons of grass, 57 per cent of the total weight of grass put in was extracted as good quality silage. Considering the very small size of the trenches, and taking into account that the silage extracted contained six per cent less moisture than the grass ensiled, this seems a very satisfactory recovery.

Velvet Bean

Velvet bean grows well in Central Tanganyika and even during the drought years between 1953 and 1955 very satisfactory yields were obtained from six varieties grown. Average yields of green fodder in 1953 and 1954 amounted to 5,034 lb. and 7,891 lb. per acre, while the highest yield for any one variety was 12,112 lb. Average seed yields for all varieties grown were 884 lb. and 861 lb. per acre respectively and 1,293 lb. in 1955 from a total of 11 different varieties.

Original planting material was obtained from the Ukiriguru Agricultural Experimental Station, from Southern Rhodesia and from the United States of America.

Details of production for the different varieties are given in Table III.

GENERAL

Although the account given includes only a few fodder plants which possess certain desirable characteristics, in so far that they might either be very high-yielding, or easily established, the remarks regarding their careful management apply equally to the numerous grass species and to other fodder plants of which no mention has been made. Even some

TABLE III

VARIETY	WEIGHT OF DRIED SHELLLED SEEDS IN LB. PER ACRE				WEIGHT OF GREEN FODDER CUT IN LB. PER ACRE	
	1953	1954	1955 (planted 7-12-54)	1955 (planted 28-1-55)	1953	1954
Local White	1,384	895	219	667	—	8,877
Somerset	781	1,508	1,552	1,323	6,096	12,112
Local Black	469	653	697	202	4,306	8,920
No. 52	974	944	1,111	778	4,105	4,477
Jubilack No. 54	804	464	1,446	1,036	5,798	5,667
No. 77	894	702	888	690	4,863	7,292
No. 5	—	—	—	1,775	—	—
No. 11	—	—	—	1,775	—	—
No. 14	—	—	—	1,613	—	—
No. 16	—	—	—	1,775	—	—
No. 18	—	—	—	1,979	—	—

of the species that might normally be regarded as most inferior would produce much better results under close management, and could provide useful fodder instead of becoming undesirable "weeds" on the land.

As far as practical management is concerned, these desirable conditions can be obtained by several different methods or by a combination of these:

- (a) Close rotational grazing using a relatively large number of cattle on a given area until the herbage is closely cropped; then moving on to the next part of the field, close herding, electric fencing or a system of intensive paddocking being required. Grazing should be followed by weeding of undesirable plants left on the field or by cutting the remaining herbage with a mower.
- (b) Cutting the surplus herbage half-way through the rainy season for silage, hay, bedding or compost to allow a fresh growth of grass. This method, like that of close grazing, removes the top

hamper and weed growth, thus allowing more vigorous growth and the formation of a better soil cover by giving the spreading grasses an opportunity to develop.

- (c) If the surplus herbage cannot be disposed of by one of the methods described it might be necessary to burn what is left at the end of the dry season thereby encouraging fresh growth when the rains begin.

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COTTON PEST CONTROL IN THE EASTERN PROVINCE, TANGANYIKA

By K. S. McKinlay, Colonial Agricultural Insecticides Research Unit,
Urambo, Tanganyika

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During 1955 the Colonial Agricultural Insecticides Research Unit carried out a series of insecticide trials on cotton at Ilonga Research Station in Eastern Province, Tanganyika. These experiments were based upon work done by the unit at Ilonga in the previous year and also upon earlier work done by Valentine and Bebbington of the Empire Cotton Growing Corporation. As far as possible the 1955 experiments were designed so as to give a broad picture of the possibilities of the cotton crop in the area and to relate the effects of pests attack and insecticidal control to other agronomic factors.

Potential Cotton Yields in the Area Experiment 1

The first experiment was designed to obtain information on possible maximum yields in the area and on the effect of planting date and insect attack upon these. Three lots of cotton were planted at monthly intervals and half of each planting was sprayed throughout the period of insect attack to give a total of six treatments as shown in Table I. The experiment was laid out in randomised blocks and there were five replications of each treatment. Individual replicates were 1/40th-acre plots and the final spacing was 6 in. between plants and 3 ft. between rows. Almost complete protection from insects was obtained by spraying to run-off at weekly intervals with an emulsion containing 0.1 per cent D.D.T. and 0.025 per cent Gamma B.H.C. This treatment is, of course, uneconomic but the main aim was to obtain cotton entirely free from insect attack so that losses on untreated cotton could be estimated. It is difficult to estimate the amount of interference between treated and untreated plots but observation throughout the season did not suggest that this was great enough to have any large effect on the results.

During the season the unprotected plots suffered from an early and very heavy Jassid attack and this was followed by severe Bollworm damage. (*Earias* sp. and *Heliothis armigera*.) Counts were made of the numbers of flower buds damaged by Bollworm ("flared

squares") each week throughout the season. These counts, recalculated as mean numbers of flared squares/20 plants/week are shown in Table I:

TABLE I—MEAN NUMBER OF FLARED SQUARES PER TWENTY PLANTS PER WEEK

Planting Date	Sprayed	Not Sprayed
January 28, 1955 ..	2.99	8.38
February 28, 1955 ..	1.34	22.86
March 29, 1955 ..	0.28	30.40

All significantly different at the 1 per cent level.

The main points of interest are the increased severity of Bollworm attack on the later plantings but in spite of this there was better control by spraying. This more efficient control on the later-planted sprayed plots was due to the smaller size of the later plants.

Table II shows the yields obtained on the various treatments:

TABLE II—YIELDS IN POUNDS OF SEED COTTON PER ACRE

Planting Date	Sprayed lb.	Not Sprayed lb.
January 28, 1955 ..	3,191	1,733
February 28, 1955 ..	2,469	482
March 29, 1955 ..	1,630	94

Least significant difference:

5 per cent level = 262 1 per cent level = 357.

The effect of planting date on yield is very marked in both protected and unprotected cotton and, whilst insects caused very heavy damage on all plantings, the earliest planting had a sufficiently long growing season to yield well in spite of this. From an economic point of view it would obviously be most profitable both to plant early and also to use insecticides to prevent damage.

Effect of Loss of Fruiting Points Experiment 2

The cotton plant forms flower buds, and hence potential cotton-producing bolls, throughout the season. The plant may not be

able, for physiological reasons, to bring all its buds to fruition, thus the loss of any particular flower bud to insects does not necessarily represent a loss of yield. Since it is important to reduce the number of insecticide applications to a minimum in order to reduce costs, it is important to know the point at which loss of fruiting points will also represent a loss of yield, for it is obviously not worth using insecticides before this time.

Experiment 2 was designed to obtain some information on this point. Cotton was planted on three different dates and on each planting all flower buds were removed by hand at weekly intervals for 0, 1, 2 and 3 months after the appearance of the first flower buds. This gave a total of 12 treatments each of which was replicated 10 times using a randomised block layout. Individual replicates consisted of 3 rows of cotton 10 yards long, the plants being at 6-in. intervals in the row. Records of yield were made on the central rows only, to avoid as far as possible shading effects between adjacent early- and late-planted plots. This cotton was protected throughout the season from any loss of flower buds to insects by spraying weekly to run-off with a 0.1 per cent D.D.T./0.025 per cent B.H.C. emulsion. Yields from this experiment are given in Table III:

TABLE III—YIELDS IN POUNDS OF SEED COTTON PER ACRE

BUDS REMOVED FOR	PLANTING DATE		
	28-1-55	28-2-55	29-3-55
0 months	2,743	1,757	899
1 month	2,502	1,415	605
2 months	2,003	1,343	482
3 months	1,636	727	281

Least Significant Difference 5 per cent level = 286
1 per cent level = 378

Under the conditions of this experiment planting date had a very large effect upon yield. Analysis showed no interaction between dis-budding and planting date, i.e. the effect of the loss of buds for a given period was the same regardless of planting date. Complete loss of all flower buds for the first month only caused a significant reduction on the last two plantings, but removal for longer periods caused a severe reduction on all plantings. However, one must expect that the effect will vary from year to year and place to place and will be determined by the length and quality of growing season and also length and duration of insect attack.

Choice of Insecticides

Having investigated the potential yields in the area and the interaction between planting date, insect damage, and yield, there still remains the question of choice of insecticide treatment. Principal results of a trial comparing four different insecticides each at three different concentrations are given in Table IV. All treatments were compared with and without the addition of B.H.C. at $\frac{1}{4}$ lb. per acre per application. The principal pests were American and Spiny Bollworms (*Heliothis armigera* and *Earias* sp.), but in the early part of the season there was also a heavy attack of Jassid (*Empoasca* sp.). In this area there is always a risk of an attack of cotton Aphis (*Aphis gossypiae*); and the purpose of trying each insecticide with and without Gamma B.H.C. was to find which insecticides could prevent or control Aphis attack alone and which needed the addition of B.H.C. In this particular year the Aphis attack did not develop, possibly due to early planting of the cotton, so that any differences in yield with and without the addition of B.H.C. are possibly due to more efficient control of the Bollworm.

For the farmer the best insecticide treatment is the one which gives the greatest profit and since insecticides vary in cost the cost of the insecticide and the value of the crop is given for each treatment.

In a discussion of these results it should first be noted that Endrin at 2 lb./acre/application gives a lower yield than the 1 lb./acre rate. Since the higher dosage gave, on counts of damaged buds, better control of Bollworm, there is a suggestion that Endrin at high dosages has a depressing effect on the cotton.

The biggest yield, 2,592 lb. of seed cotton per acre, was given by weekly applications of 1 lb. of Endrin per acre plus $\frac{1}{4}$ lb. of Gamma B.H.C. per acre. However, the greatest profit was given by weekly applications of D.D.T. alone at 1 lb. per acre although the yield, 2,232 lb. of seed cotton per acre, was lower. The cheapest treatment to give a reasonable return was D.D.T. alone at $\frac{1}{4}$ lb. per acre.

Thus alternative recommendations would be D.D.T. alone at $\frac{1}{4}$ lb./acre (this would involve the smallest outlay on insecticides), or D.D.T. alone at 1 lb. per acre, when outlay on insecticides would be larger but final profits increased.

TABLE IV—YIELDS AND COSTS OF INSECTICIDE TREATMENT

INSECTICIDE LB./ACRE/APPLICATION	DIELDRIN			ALDRIN			ENDRIN			DDT		
	$\frac{1}{4}$ lb.	1 lb.	2 lb.	$\frac{1}{4}$ lb.	1 lb.	2 lb.	$\frac{1}{4}$ lb.	1 lb.	2 lb.	$\frac{1}{4}$ lb.	1 lb.	2 lb.
Yield, lb. seed cotton per acre	1,634	2,102	2,419	1,267	1,469	1,771	2,081	2,369	2,203	1,836	2,232	2,232
Value in Sh./acre (Grade 1 at 61 cts. lb.)	997	1,282	1,476	773	896	1,080	1,269	1,445	1,344	1,120	1,362	1,362
Cost of treatment. 8 weekly applications. Sh./acre insecticides only.	62	250	499	47	187	373	83	332	664	19	76	152
Difference (value less cost of treatment) Sh./acre..	935	1,032	977	726	709	707	1,186	1,113	680	1,101	1,286	1,210
WITH BHC AT $\frac{1}{4}$ LB./ACRE												
Yield	1,937	2,167	2,347	1,562	1,692	1,922	2,189	2,592	2,556	2,095	2,167	2,203
Value	1,182	1,322	1,432	953	1,032	1,172	1,335	1,581	1,559	1,278	1,322	1,344
Cost	140	327	577	124	264	451	161	410	741	97	154	230
Difference	1,042	995	855	829	768	721	1,174	1,171	818	1,181	1,168	1,144

Yields. Least Significant Difference 5 per cent = 53 lb.
1 per cent = 71 lb.

All insecticides applied as low volume sprays at 12 gals./acre using hand-operated knapsacks. The standard treatment using 3 per cent BHC/10 per cent DDT as a dust should cost about Sh. 72. Cotton planted 14-2-55. Individual plots 1/10th acre. 5 replications per treatment.

However, the use of D.D.T. alone leaves a risk of Aphis build-up and this risk can only be covered by using Gamma B.H.C. at $\frac{1}{4}$ lb./acre/application in addition. Alternatively Endrin may be used alone at $\frac{1}{4}$ lb./acre since previous experiments have shown it will control both Aphis and Bollworm. The time at which spraying should be started and the number of applications necessary depends upon local conditions, and may vary. However, where Bollworms are moderate to severe, eight applications at weekly intervals during the flowering period should enable the plant to set a good crop.

Methods of Application

Finally, one has to choose the most suitable method of application. Table V summarises the results from an experiment in which several methods of application were compared.

TABLE V—METHODS OF APPLICATION

A *Swaine Duster*.—Hand-operated bellows type. Cost: Sh. 5 to 7.

B *Procall Rex Duster*.—Rotary hand-duster. Cost: £12.

Both dusters applied 3 per cent B.H.C./10 per cent D.D.T. dust at 10 lb./acre/application. 1 lb. D.D.T. and 0.3 lb. B.H.C./acre/application.

C *Low-volume Spray*.—6 gal./acre. Hand-operated knapsack sprayer. Single nozzle

directed upwards so that spray spread and drifted, treating two rows at once. Operator walked steadily between alternate rows at approximately 2 m.p.h.

D 100 gal./acre.—Hand-operated knapsack sprayer. Operator sprayed both sides of every row.

Both sprayers applied 1 lb. D.D.T. and $\frac{1}{4}$ lb. B.H.C. per acre/application giving same amount of active ingredient per acre as dusts.

E *Run-off Spray*.—Plants sprayed to run-off with 0.1 per cent D.D.T./0.025 per cent B.H.C., approximately 300 gal./acre.

F Nil control.

	A	B	C	D	E	F	L.S.D. 5% level
Man hours/acre/application ..	1	1	1	4	24	—	—
Flared Squares/20 plants/week during treatment ..	28	27	9	3	4	22	8
Yield ..	635	665	1,222	1,616	2,024	217	240

Cotton planted 17-2-54.
Spacing 3 ft. by 6 in.
Plots 1/10th acre, 5 replications/treatment.
Eight weekly application, first on May 13th.

There was no difference in efficiency between the cheap and the expensive duster, but dusts were much less effective than any of the sprays. The lower efficiency of the dusts was possibly due to the difficulty of applying them to cotton which grew to over 5 ft. high. In the previous year when the cotton was planted late, and was only 3 ft. high when applications were made, dusts and low-volume sprays were equally effective.

The low-volume spray, 6 gal./acre, was less effective than the same amount of insecticide applied in 100 gal. of water per acre. No treatment gave the same degree of control as the run-off spray. Final choice of method involves other factors than relative efficiency and the main factors governing choice are given below:

Run-off Spray.—100 gal./acre, high volume. Applications not limited by meteorological conditions. Efficient control of Bollworm. Water requirements excessive.

Dusts.—No water needed. No mixing since insecticides are received ready to apply. Not very efficient control of pests on tall plants. Applications limited to early morning or evening when air is still.

Low-volume Sprays.—Possibly best compromise between water requirements and efficiency.

Interval Between Applications

This aspect was not covered during the 1955 experiments but previous work at Ilonga has shown that the optimum interval is seven days. This is not entirely due to loss of insecticide by weathering but also to the rapid formation of new, and hence unprotected, buds by the cotton plant during the intervals between applications.

Standards of Cultivation

Yields on these experiments were very high and it is felt that this was due to early planting and good cultivation. Late planting and poor cultivation can reduce yields to the point where the value of the protected crop would not pay for the insecticides. This is particularly the case with the peasant-grown crop in this area where standards of cultivation will have to be raised before insecticides can be used with real profit.

SUMMARY

This paper reports a series of experiments at Ilonga Research Station, Eastern Province, Tanganyika, on the use of insecticides to control local cotton pests and on the interaction between time of planting, amount of insect damage and yield. The best yields were obtained by planting the cotton as soon as rainfall made it possible. Whilst loss of all flower buds for the first month of flowering made only a small difference to the yield, loss over a longer period would make the use of insecticides necessary and profitable. The choice of the best insecticide treatment is difficult; but of those tested the two best were either a mixture of 1 lb. D.D.T./ $\frac{1}{4}$ lb. Gamma B.H.C./acre/application or Endrin at $\frac{1}{4}$ lb./acre/application, to be applied in 6–12 gal. of water per acre at weekly intervals during the period of insect attack.

Time of planting and quality of cultivation have an overriding effect upon yield.

ACKNOWLEDGMENTS

I thank Mr. G. Poulton and Mr. E. P. Kanya, without whose assistance this work could not have been done.

RESPONSES TO FERTILISERS UNDER FARMING CONDITIONS IN THE SOUTHERN PROVINCE OF TANGANYIKA

By A. C. Evans* and L. R. Wilson, Tanganyika Agricultural Corporation

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Responses to fertilisers recorded on experimental farms can only be used as approximations to those likely to be given under the conditions existing on a production farm, where close supervision at planting time cannot be given and planting often has to be done when soil conditions are not at their best. An opportunity was taken in the 1955 season at Nachingwea to measure the responses to fertilisers by four crops, groundnuts, maize, soya and sorghum, planted on a production farm. The rains began a month late, 12th January, so planting was late. Adequate rain fell during the next 16 weeks so the results recorded can probably be considered as having been obtained in a reasonably good year.

The farm is situated just to the east of Nachingwea on the Nachingwea soil series. A description of this soil is given in [1]. The fertility level of the soil varies considerably from place to place, rather more than is usual for the area farmed by the Corporation. Three large fields are divided into blocks for convenience of cropping and access, and into panels by conservation terraces. Panels vary considerably in size from fractions of an acre to five acres. Approximately one-third of the panels were used in this survey. For groundnuts, sorghum and soya, to which fertiliser was applied only in the seedbed, an unfertilised strip of crop was planted for the length of the panel. Maize received a top dressing of sulphate of ammonia in addition to a seedbed application, so half of the strip not receiving seedbed fertiliser was given top dressing, and a further strip that received seedbed fertiliser was not given a top dressing. Two sets of yield samples per panel were taken for each crop. Plant numbers were also recorded. At planting time a rough estimation of the amount of fertiliser applied to each panel was made.

RESULTS

Maize

Maize was planted on two fields, one of which had a belt of very poor soil running

through it. Results are presented separately for good and poor soils on this field.

TABLE I—EFFECTS OF SEEDBED AND TOP-DRESSING APPLICATIONS OF SUPERPHOSPHATE AND SULPHATE OF AMMONIA TO MAIZE

Field	147		150
	Good	Poor	Good
Seedbed application of:			
Double Super, lb. per acre	109	109	84
Sulphate of ammonia, lb. per acre	36	36	28
Top dressing of sulphate of ammonia, lb. per acre	36.5	36.5	36.5

lb. of grain per acre

Nil	1,947	662	1,486
Seedbed only	2,164	458	1,913
Top dressing only	1,886	531	1,714
Both	2,561	565	2,363
Significant differences:			
5 per cent	392	321	291
1 per cent	542	445	390

On the poor soil fertilisers did not give any increase in yield. On the good soil of field 147, seedbed and top-dressed applications alone had no significant effects but when both were applied a highly significant response of 614 lb. per acre was obtained. On field 150 the seedbed application alone and with the top dressing gave highly significant responses, in the latter case of 877 lb. per acre.

Groundnuts

Groundnuts were planted on two fields.

TABLE II—THE EFFECT OF SINGLE SUPERPHOSPHATE ON YIELDS OF GROUNDNUTS

lb. of kernels per acre

Field	150	151
Superphosphate, lb. per acre ..	113	127
Nil	992	778
Fertiliser	980	956
Significant difference:		
5 per cent	112	118
1 per cent	160	151

* Now at the Department of Agriculture, Dar es Salaam, Tanganyika Territory.

On field 151 a highly significant response of 178 lb. of kernels was obtained. On field 150 fertiliser had no effect on yield. Since maize gave a response to seedbed fertiliser on an adjoining part of the same field this result was unexpected. It is possible that the response shown by maize was largely due to the sulphate of ammonia applied in the seedbed and as a top dressing.

Soya

Soya was only planted on one field. Results showed that a band of poorer soil ran diagonally across the field and data are presented for both good and poor soils. An average of 106 lb. of single superphosphate was applied in the seedbed.

TABLE III—EFFECT OF SUPERPHOSPHATE ON YIELDS OF SOYA

lb. per acre

Soil	Good	Poor
Nil	884	374
Fertiliser	1,090	571
Significant differences:		
5 per cent	83	128
1 per cent	113	177

Both areas gave a highly significant response of about 200 lb. per acre, even though the yields differed considerably both with and without fertiliser. No difference in plant size between the two areas was noticed during growth.

Sorghum

Two blocks in two fields were planted to sorghum.

TABLE IV—EFFECT OF SEEDBED APPLICATION OF A MIXTURE OF SULPHATE OF AMMONIA AND DOUBLE SUPERPHOSPHATE ON YIELDS OF SORGHUM

lb. per acre

Field	150A	150B	147D	147G
Sulphate of ammonia ..	0	26	18	17
Double Superphosphate ..	53	77	52	49
Nil	187	93	450	903
Fertilised	330	480	871	1,421
Significant difference:				
5 per cent	219	66	278	170
1 per cent	315	94	293	231

Sorghum yields were generally poor, as most of the sorghum happened to be planted on the belt of very poor soil on this farm. With the exception of field 147G the yield of sorghum varied enormously from panel to panel, some panels producing virtually nothing. In spite of this variation there were highly significant responses to fertilisers on three out of four blocks.

It would appear from Table IV that higher responses to fertiliser were given on blocks having the better "basic" fertility. The three blocks showing significant responses can be divided on this basis into areas of low and high fertility and the response to fertiliser examined.

TABLE V—RESPONSE TO FERTILISER IN RELATION TO "BASIC" FERTILITY

lb. per acre

Field	150B		147D		147G	
Basic fertility ..	Low	High	Low	High	Low	High
Nil	57	129	204	680	348	1,457
Fertilised	324	635	472	1,906	575	2,267
Response	267	506	268	1,226	227	810

On each block the response to fertiliser was much greater on the area which gave the higher yield without fertiliser.

FINANCIAL RETURNS

Data on financial returns from fertilisers are only of transitory value in view of fluctuations in price of fertiliser and of crop from year to year and place to place. A brief summary however is given below since these results have been obtained in an area that offers considerable scope for agricultural development, particularly along the lines of the Corporation's African Tenant Scheme in which fertilisers must be applied to maintain yields. The prices used are for fertilisers at store price and internal crop prices for the 1955 crop.

	Price per ton £
Sulphate of Ammonia ..	24½
Single Superphosphate ..	16½
Double Superphosphate ..	30
Groundnut kernels	50
Soya	30
Maize	21
Sorghum	16

TABLE VI—COSTS AND RETURNS ON FERTILISER APPLICATIONS PER ACRE IN EAST AFRICAN SHILLINGS

Field ..	147	150	151	151	150B	147D	147G
Crop ..	Maize	Maize	Nuts	Soya	Sorghum	Sorghum	Sorghum
Cost ..	45.7	37.1	19.1	15.9	22.7	18.2	17.1
Profit ..	69.4	127.3	60.3	38.2	28.6	43.7	57.1

Thus where significant responses were recorded and they were in the majority of cases, worthwhile financial gains have been obtained.

GENERAL

A number of points of general interest arose out of the survey. No relationship could be found between the magnitude of the responses and the amount of seedbed fertiliser estimated to have been applied per acre to the different panels, even though this varied considerably as shown by the following figures:

	<i>lb. per acre</i>			
Maize	..	..	..	77-210 84-228
Groundnuts ..	..	..	..	81-129 93-190
Soya	..	..	..	39-153
Sorghum	..	..	..	44-57 57-83 51-89 81-144

Results of fertiliser experiments suggest that at the higher levels of application a large proportion of the fertiliser would have little effect, at least in the current season. Thus a considerable saving could be made by ensuring that a more accurate approximation to the desired rate of application be achieved, probably by actuating the delivery mechanism directly from the tractor rather than from the press wheels of the planter.

On the belt of poor soil running through the farm small patches of well-grown sorghum were very evident. Ninety per cent of these patches showed definite signs that they were located on ash sites where tree trunks, etc., had been piled and burned when the land was cleared. An estimate was made of the yields of such patches and the surrounding areas.

RANGE OF YIELD IN LB. PER ACRE			
Ash areas	..	..	909-1,739
Controls	..	..	0-427

Thus even in the fourth year of cropping the ash was having a marked effect on yield. On another field it was noticed that, where sorghum stubble had been piled into swaths and burned, the maize was definitely greener than on the rest of the field.

Since phosphate was applied in the seedbed it is not likely that the good growth of sorghum on the ash areas was due to a residual effect of this element or of calcium but rather to an increased supply of a minor element. The better appearance of the maize in the presence of burned sorghum stubble suggests that even on soil yielding 2,560 lb. per acre there is a possibility that continued cropping might reduce the amount of such an element to a level that would be a limiting factor in production. Unfortunately the effect of burned stubble on yield was not estimated.

Two experiments were laid down to test the value of phosphate, potash, lime and magnesium for this poor soil. Potash and magnesium showed no effects. On maize phosphate showed no effects and for groundnuts slight but non-significant effects. Lime gave significant increases in yield for both crops.

TABLE VII—EFFECT OF LIME ON YIELDS OF MAIZE AND GROUNDNUTS

		<i>lb. per acre</i>				
Rate	..	Nil	One ton	Two tons	Sig. diff.	
					5%	1%
Groundnuts ..	..	376	422	488	41	56
Maize	..	1,138	1,476	1,626	218	312

The responses were not of immediate economic value but it is likely that the effect of lime will last a number of years and might be greater in later years when it would be thoroughly incorporated in the soil.

We are grateful to Mr. Cyril Gladwyn for permitting us to carry out this investigation on his farm.

REFERENCE

- [1] Overseas Food Corporation, *Annual Report and Statement of Accounts* (1952-53). H.M. Stationery Office.

A STUDY OF A ROSETTE-RESISTANT GROUNDNUT VARIETY, ASIRYA MWITUNDE

By A. C. Evans, Tanganyika Agricultural Corporation*

(Received for publication on 20th March, 1956)

The variety Asirya Mwitunde has proved useful for combating rosette disease of groundnuts, which was so severe in the Urambo area farmed by the Tanganyika Agricultural Corporation that groundnut production ceased. In the Nachingwea area the disease threatened to eliminate production of the crop. The mechanism of resistance has been worked out (Evans, 1954). The vector of the disease, *Aphis craccivora koch*, reproduces more slowly on this variety than on others, and a lower proportion of aphids feeding on diseased plants become infective. The variety shows some tolerance to the disease except in the early stages of growth. Furthermore, it produces dormant seeds, so that volunteers do not appear immediately after harvest to carry virus and vector through the dry season into the next rainy season.

Asirya Mwitunde was first grown by the Corporation in the Urambo area, being introduced from the Tabora district. It suffered from rosette disease as severely as Natal Common, the other variety grown, chiefly because of the overwhelming incidence of infective winged aphids produced on rosetted volunteer Natal Common plants present on adjacent fields during the first weeks of growth of the new crop. Its value was recognised and proved in the Nachingwea area; trial plantings in 1953 yielded 710–1,040 lb. of kernels per acre compared with 0–650 lb. for Natal Common in a year when rosette disease was severe. In 1954 and 1955 the variety was grown generally and only occasional diseased plants were found. Average farm yields were satisfactory, 1,050 lb. of kernels per acre in 1954 and 850 lb. in 1955.

During 1948–1953 Natal Common, a short-season variety, was mainly used in research work on groundnuts. With the discovery of rosette resistance in Asirya Mwitunde and its adoption as the only variety grown by the Corporation at Nachingwea, current research is chiefly devoted to this long-season variety.

DESCRIPTION

As originally obtained Asirya Mwitunde was a mixture of prostrate and semi-upright, dark

and light green-leaved, few- and many-branched plants; tan and dark red seeds, and non-dormant and dormant seeds. Plants with light green leaves were found to be susceptible to the *Cercospora* leaf spots, and had non-dormant seeds. Undesirable types, prostrate, light-green leaf and short-season strains were partly eliminated by field and seed selection on farms and a programme of single line selection was begun. The variety may now be defined as a long-season, 120–130 days, dark-green leafed, semi-upright variety bearing 8–12 main branches, with dormant seed, the testa of which is dark red, the pods containing two seeds, rarely three. It is distinct from other varieties in the expression of symptoms when affected by rosette disease (Evans, 1953).

GROWTH

Growth studies were made on plants spaced at 2 ft. in the row and 3 ft. between rows. Natal Common was used as a typical short-season variety for comparison. For the first 30 days no appreciable difference in leaf and branch number could be noted between the two varieties (Fig. 1). Flower production began at approximately the same time in both varieties but was much more intense in Natal Common. The curve for flower production shows the number of fresh and senescent flowers not subtended on pegs at any one time.

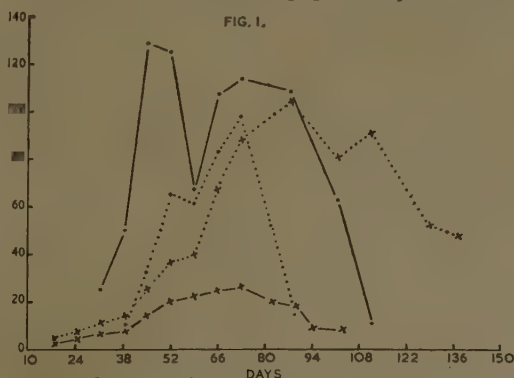


FIG. 1.—Increase in numbers per plant during the growth period of leaves —, flowers, on Natal Common x x x and Asirya Mwitunde ..

* Now of the Department of Agriculture, Dar es Salaam.

After 30 days the more luxurious growth of Asirya Mwitunde is shown by the more rapid increase in leaf and branch number, since it produces four to five times as many leaves and branches as Natal Common. The leaf curve for Natal Common is rather flattened, as leaf-fall of the oldest leaves caused by *Cercospora* leaf spots, occurred earlier in this variety. The drop in flower production shown by Natal Common between 45 and 59 days and by Asirya Mwitunde between 52 and 59 days was possibly caused by a rainless period which occurred between the 7th and 28th days after emergence.

The first pegs appeared at the same time in both varieties, but more were produced by Natal Common (Fig. II). The interruption in flowering caused by the drought is clearly reflected in peg production for Natal Common and perhaps just perceptibly for Asirya Mwitunde. Peg production continued in both varieties until they had nearly reached maturity. Immature pods appeared appreciably earlier in Natal Common than in Asirya Mwitunde and reached a maximum earlier, the time lag being approximately 20 days. Similarly, mature pods appeared about 20 days earlier in Natal Common. Although total flower production was approximately the same in both varieties, Asirya Mwitunde produced the greater number of pegs and immature pods but the same final number of mature fully-filled pods. The high proportion of partially-filled pods carried by Asirya Mwitunde at the end of the growth period is often regarded with disfavour, as evidence that it has not produced its full yield. These should rather be regarded as ensuring an adequate yield if growth conditions are not fully favourable during the early period of growth of the pods, i.e. young pods damaged by insects can be replaced. Asirya Mwitunde is grown as an annual, but examples have been noted of plants missed by the plough surviving the dry season and breaking into new growth at the onset of the rains. Most species of *Arachis* are perennial. Thus Asirya Mwitunde might behave as a biennial or perennial if moisture conditions were suitable. If this is so, a high proportion of immature pods must be accepted as a characteristic of the variety and not as an abnormality. The period elapsing between the appearance of the first mature pod and full maturity is only about 20 days for Natal Common, as compared with about 40 for Asirya Mwitunde. The kernel of the Asirya Mwitunde is larger than that of Natal Common, 0.55 g, compared with 0.34 g.

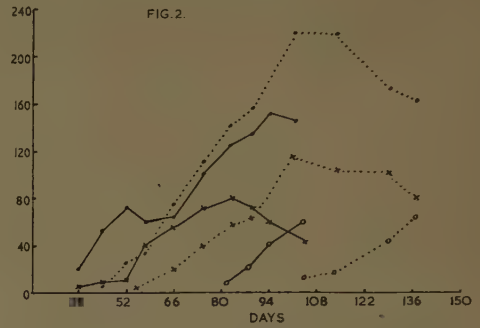


FIG. II.—Increase in numbers per plant during the growth period of pegs . . . , immature pods x x x and mature pods o o o. Natal Common — and Asirya Mwitunde

A more detailed study of pod and kernel production by Asirya Mwitunde was carried out at a normal field spacing of 26,000 plants per acre or an average spacing of 7 in. between plants. Samples, each 6 ft. of row, were dug every ninth day from the 58th day onward. Two adjacent areas were sampled, one of which proved more productive than the other, and results are presented separately for each. Full-sized but immature pods, i.e. containing an undeveloped kernel, were present on the 58th day. The number of full-sized pods per plant continued to increase until about the 94th day (Fig. III) after which it remained roughly constant at 21 and 27 per plant for the less and more productive areas respectively. The first fully mature nuts were observed on the 94th day. The shelling percentage increased rapidly

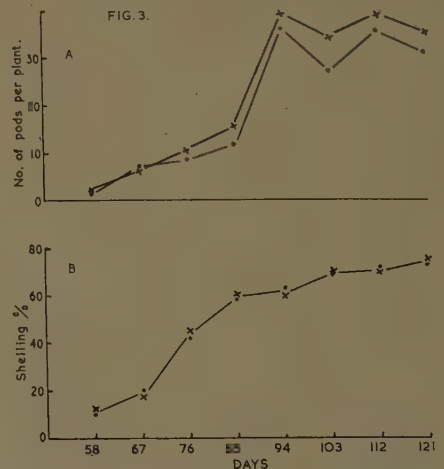


FIG. III.—Asirya Mwitunde. A—Increase in numbers of full-sized pods during the growth period. B—Increase in shelling percentage during the growth period. x more productive area, o less productive area.

between the 67th and 85th day, after which it increased slowly until the plants became nearly leafless as a result of *Cercospora* leaf-spot attack.

Husk production increased steadily until the 94th day and then remained approximately constant (Fig. IV). Kernel production occurred at approximately the same rate on both areas until the 85th day. Thereafter the rate of increase was greater on the more productive area, approximately 32 lb. per acre per day, than on the poorer area, 20 lb. The maximum yield was produced on both areas by the 112th day. Maturity occurred early in 1955 when this work was done, as the onset of the planting rains occurred a month later than usual, and on the area sampled *Cercospora* leaf-spot disease was more severe than normal. At the final date of harvest a high proportion of the plants were moribund and broken up, and most of the pods had become detached from the plants. The continued high rate of kernel production, so long as the plant remains whole and can be handled as a unit, poses an important practical problem. If the crop is dug too early then the maximum yield is not obtained, if too late a high proportion of the pods remain on the ground and heavy gleaning costs are incurred. The relationship between time of digging and yield will be discussed below.

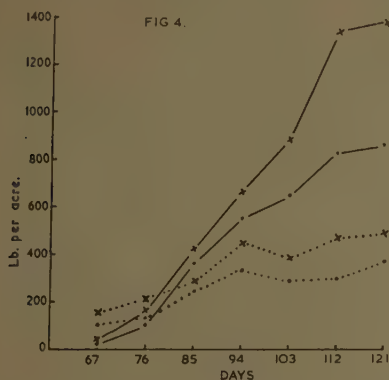


FIG. IV.—*Asirya Mwitunde*. Increase in weight of husks ... and kernels — during the growth period. x more productive area, o less productive area.

PLANT SPACING

Plants spaced at 2 ft. apart in the row produce an average of 60 pods per plant; when more closely spaced, i.e. 7 in. apart, this number is reduced to just over 20 pods per plant. Population studies on Natal Common (Overseas Food Corporation, 1949), have shown that

high populations at harvest time are necessary for high yields. Since long-season varieties produce much larger plants than short-season varieties it appeared possible that plant population might not be so important in securing high yields. Data from a survey of responses to fertiliser application under ordinary conditions of farming are available to test this supposition (Table I).

TABLE I—REGRESSION COEFFICIENTS AND MEAN YIELDS PER THOUSAND PLANTS IN LB. KERNELS, 1955

Field	Regression Coefficient	Mean Yield
A	+ 31.1	54.4
B Unfertilised	+ 26.6	33.2
B Fertilised	+ 30.4	42.3

In field A a significant response to fertiliser was not obtained. In field B a highly significant response was obtained and figures are presented for fertilised and unfertilised plants. All regression coefficients are highly significantly different from nought and high in relation to the mean yield per 1,000 plants, showing that low populations led to considerable loss in yield. This is illustrated for field A in Table II.

TABLE II—RELATIONSHIP BETWEEN YIELD, LB. KERNELS PER ACRE, AND PLANT POPULATION IN THOUSANDS PER ACRE FOR THREE FIELDS

Plant Population	Yield Produced	Theoretical
12.6	625	816
16.1	969	924
26.5	1,211	1,246

At Nachingwea rain can be expected to fall, on the average, for 124 days after the first suitable rains for planting have fallen (Evans, 1955). There is wide variation from year to year, but the risk of planting a variety requiring 120–130 days to mature is not inconsiderable. None of the 163 single-line selections tested in 1954 showed promise of earliness. Fig. II shows that about 20 mature pods per plant were present at 114 days. This suggested the possibility that, with a closely-planted stand, there might be sufficient mature nuts to give an economic yield at about this time. If only 10 mature pods were produced by each plant a population of 41,000 plants per acre would be required to produce 1,000 lb. of

kernels. A reduction of about 15 to 20 days in the length of the growing period would considerably increase the chances of obtaining economic yields.

An experiment was planted late in the season to test the effect of spacing on the number of pods produced. Spacings of 2-12 in. in the row were tested.

TABLE III—NUMBERS OF FULL-SIZED PODS AND GROWING PODS PER YARD OF ROW AT VARIOUS SPACINGS

Days after planting	75		93	
Spacings between plants, inches:	Full-sized	Im-mature	Full-sized	Im-mature
2	57	54	73	82
4	50	52	78	83
6	42	45	62	70
8	40	41	58	64
12	30	28	57	62

At both times the number of full-sized and growing pods was greater at the closer spacings. At 75 days the 2-in. spacing carried twice as many full-sized pods as the wider spacing. By 93 days, however, the disparity was not so great, but the 2- and 4-in. spacings carried appreciably more pods than the 8- and 12-in. spacings per unit length of row. The experiment was planted too late to give yield data, but it does appear that very close planting might produce sufficient early pods to give an economic yield in a short season. Assuming a spacing of 4 in. in 34-in. rows and 78 pods per yard run, the yield would be just over 900 lb. of kernels per acre. In a late-planted experiment, 31st January, 1955, a mean population of 53,000 plants per acre was achieved, an average spacing 3.5 in. in the row, and the average yield was 1,040 lb. of kernels per acre 108 days after planting.

Thus by planting at a seed rate of 70-80 lb. per acre it would appear possible to treat Asirya Mwitunde as though it were a short-season variety. Further work on this possibility will be done.

A further advantage can be gained from close spacing. It has been noticed in the field that when plant populations are high the plants do not spread out so much between rows as they do when populations are low. Harvesting can thus proceed more quickly as the digger blades are not clogged so frequently with a mass of tangled plants.

TIME OF HARVESTING

One of the important factors governing successful groundnut production is the time of maturity at which the nuts are dug from the ground. Fig. V shows the results obtained in three harvesting experiments. The two experiments showing high yields were planted early, and rainfall was good throughout the growing period; the low-yielding experiment was planted very late owing to the late onset of the rains in 1955, but good rains fell during the growing season. Although maximum production was reached at differing times of maturity the three experiments show very similar trends. There is a period of about 10-14 days during which the plants can be dug and carry with them almost all the pods. Once the period of maximum production is passed there is a great increase in the weight of pods left in and on the soil. The descent of the curve for "total recovered" show that very appreciable irrecoverable losses occur if digging is left too late. It is better to harvest a little early, before the time of maximum production than to incur the risk of appreciable loss and the extra cost and trouble of gleaning.

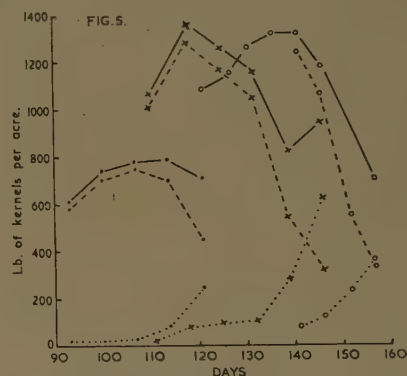


FIG. V.—Effect of time of harvesting on yield of *Asirya Mwitunde*.
— total recovered ° Urambo 1954
--- harvested from stook x Nachingwea 1954
..... gleaned . Nachingwea 1955

GENERAL

In the Nachingwea area soil fertility varies considerably from place to place, and groundnuts (*Natal Common*) have given responses averaging 125 lb. of kernels per acre to an application of 100 lb. of single superphosphate per acre. *Asirya Mwitunde* has not been so extensively tested as *Natal Common* but responses varying from 0-225 lb. of kernels per acre have been recorded for the above application of fertiliser. Whether the whole response is to phosphate is doubtful.

TABLE IV—EFFECT OF SINGLE SUPERPHOSPHATE AND OF RESIDUAL SULPHATE OF AMMONIA

Yields in lb. of Kernels per Acre, 1955

Sulphate of Ammonia, lb. per acre, 1954	SINGLE SUPERPHOSPHATE LB. PER ACRE, 1955			Mean
	0	100	200	
0	1,046	1,161	1,237	1,148
100	1,213	1,434	1,346	1,331
200	1,230	1,422	1,400	1,351
Mean ..	1,163	1,339	1,328	

Significant differences ..	Body of Table	Means
P = .05	215	124
P = .01	281	162

The sulphate of ammonia had been applied to a previous crop of sorghum in this experiment. The responses to single superphosphate, 170 lb., were highly significant, no significant difference being shown between the two rates of application. The mean response to residual sulphate of ammonia was 193 lb. per acre; again there was no significant difference between the two rates of application. Greenwood (1952) has recorded sulphur as being beneficial to groundnuts in Nigeria, and Mills (1954) has recorded high responses to residual sulphate of ammonia in Uganda.

In 1950 three experiments were performed on newly-cleared land adjacent to the site of the above experiment. Superphosphate and sulphate of ammonia were among the treatments applied. A combined analysis of variance showed that responses to both fertilisers were highly significant and that the interaction was not significant.

TABLE V—AVERAGE RESPONSES TO SUPERPHOSPHATE AND SULPHATE OF AMMONIA, NATAL COMMON, 1950

lb. Kernels per Acre

2 cwt. triple superphosphate per acre	436
1 cwt. sulphate of ammonia per acre	193
Interaction	63
Significant differences:	
P = .05	143
P = .01	191

Since Asirya Mwitunde, as originally constituted, showed wide variations in morphological characters, a programme of selection for yield was begun using selections from plants conforming to the definition given above. In 1955 a quadruple lattice trial comparing 63 progeny lines with bulk seed was planted. The analysis of variance showed that there were highly significant differences between progeny lines and bulk seed for both unadjusted and adjusted yields. Two lines were highly significantly better than bulk for both unadjusted and adjusted yield, and one of these had given the highest yield in a preliminary sorting trial in 1954.

TABLE VI—YIELDS OF CERTAIN PROGENY LINES OF ASIRYA MWITUNDE

lb. Kernels per Acre

Line No.	1955		1954
	Unadjusted	Adjusted	
2	1,184	1,205	2,362
58	1,144	1,226	1,789
14	1,124	990	1,845
62	1,058	1,155	1,794
Bulk ..	829	854	1,800

Average significant differences 1955 only:

P = .05 197

P = .01 260

Line 2 has been outstanding compared with bulk in both years.

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LAND USE AND GRAIN YIELDS IN THE KENYA HIGHLANDS

By E. S. Clayton, Economic Research Division, The Treasury, Nairobi

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The Report on the Kenya Agricultural Census, 1954, [1] contains much useful information which, taken together, provides a broad picture of the pattern of farming in the Kenya Highlands. This article attempts to analyse some of this information with a view to discerning rotation relationships in arable farming. The cropping data relating to the four main arable areas, Naivasha, Nakuru, Uasin Gishu and Trans Nzoia, are brought together in Table I:

TABLE I—CROPPING DETAILS, 1953/54*

Crop	Naivasha	Nakuru	Uasin Gishu	Trans Nzoia
	<i>acres</i>	<i>acres</i>	<i>acres</i>	<i>acres</i>
1. Total cereals ..	114,300	133,700	157,300	95,300
Maize (Est.) ..	(650)	(42,310)	(45,331)	(80,084)
2. Roots and Row-crop ..	1,382	3,443	4,036	4,972
3. Rotational Forage	9,989	30,911	11,795	29,150
TOTAL ARABLE ..	125,671	168,054	173,131	129,422
4. Non-rotational crops ..	4,324	6,889	2,661	741
5. Plantation crops ..	281	28,146	96,360	11,282
TOTAL ..	130,276	203,089	272,152	141,445
TORORAGE RATIO ..	1:12.5	1:5.4	1:14.7	1:4.4

* The crop groups 1-5 contain the following:

1. Wheat, maize, barley, oats.
2. Potatoes, peas and beans, other vegetables, sunflower.
3. Grass leys, other fodder crops, green manure, silage, other crops.
4. Pyrethrum, fruit.
5. Sisal, tea, sugar, coffee, wattle.

In considering crop rotations, only groups 1-3 are relevant since 4 and 5 are not normally rotated. Table II shows the percentage distribution of rotated crops:

TABLE II—ROTATED CROPS PER 100 ACRES OF ARABLE LAND

Crops	Naivasha	Nakuru	Uasin Gishu	Trans Nzoia
	%	%	%	%
Small Grains ..	90	55	65	12
Maize ..	1	25	26	62
Roots and Rowcrop ..	1	2	2	4
Rotational Forage ..	8	18	7	22
TOTAL ..	100	100	100	100

And finally from the above table approximate rotations (or variations on these) in the four districts can be derived:

Naivasha

10 shift: G-G-G-G-G-G-G-G-L.

Nakuru

5 shift: M-G-G-G-L.

Uasin Gishu

15 Shift: G-G-M-G-G-M-G-G-M-G-G-M-G-G-L.

Trans Nzoia

5 shift: M-M-G-M-L.

(G = small grains; M = maize. L = rotational forage.)

The contrast between land use systems in each area is striking. In Nakuru and Trans Nzoia it is soil-conserving, resembling what is termed ley farming, but in Uasin Gishu it is soil-depleting. Indeed the ley shift in Naivasha and Uasin Gishu is so infrequent that the system is not far removed from grain monoculture. However, the census figures do not show the extent to which cropland is rested by means of a shifting cultivation. The more undeveloped farms have a reserve of untilled land which can be broken when yields begin to fall on the tillage area of the farm. Where this occurs the rotations worked out above underestimate the period of land-resting.

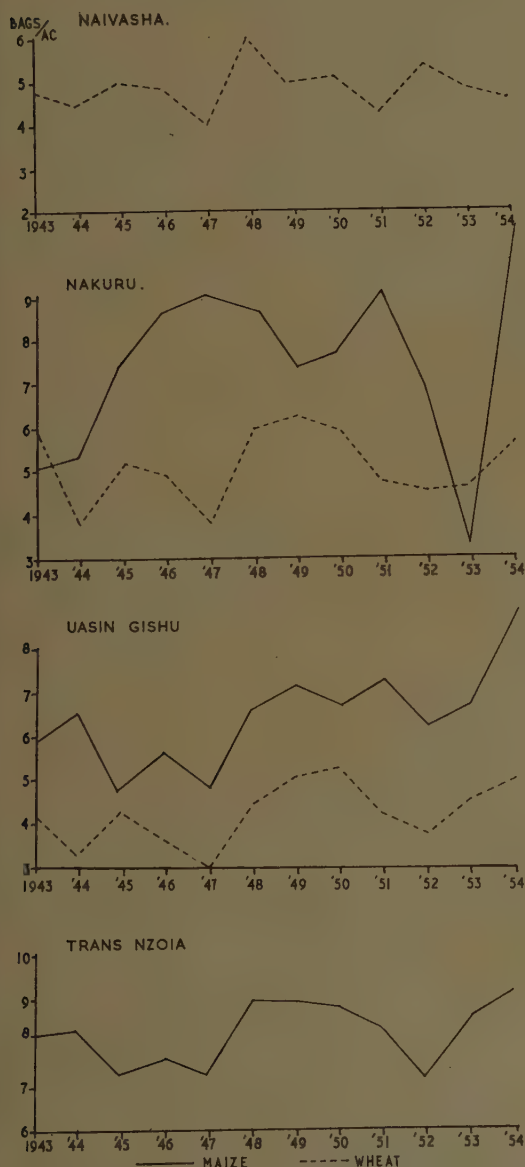
It is interesting to trace the course of wheat and maize yields in relation to land-use patterns in these areas. Yields since 1943 are shown in Fig. I.

Over the period, yields of both crops have clearly been maintained and in some areas slight increases are shown. It would be improper to ascribe a causal relationship between current cropping patterns and the trend in crop yields, because important changes have occurred in the period. Of first importance is the increased area devoted to these crops between 1943-54. Regarding wheat, this amounted in Naivasha, Nakuru and Uasin Gishu to 512 per cent, 44 per cent and 43 per cent respectively, over the 1943 acreage, and for maize in Nakuru, Uasin Gishu and Trans

Nzoia 26 per cent, 109 per cent and 45 per cent respectively. The breaking of such large areas of new land must have helped to maintain average yields. Other important changes in the period tending to prevent a yield fall on

land as found until recently in all areas. On the other hand, the improved cropping pattern in Nakuru and Trans Nzoia is too recent for yields to have shown their expected improvement.

FIG.1. YIELDS PER ACRE. 1943 - 1954



worked soils are the substantial increase in the use of artificial fertilisers and the use of improved seed varieties. These three factors have masked the effect that might have been expected from the inadequate resting of crop-

In considering the relation of yields and land use it is helpful to take into account the economics of crop rotations. Ordinarily, different farm crops compete with each other from the point of view of land and the output therefrom. This relation always applies to grain crops. On a given tillage area if a farmer wants to increase his output of wheat by 10 acres he must reduce his output of (say) oats also by 10 acres. But the relation between grain and forage crops is not so straightforward, because grasses and legumes contribute nitrogen, control erosion, eliminate pests and maintain or improve soil tilth. These factors tend to increase grain yields; thus the introduction of forage into a rotation will usually increase the total grain output from a farm in addition to the output of forage. That is, the loss of grain acres through introducing forage is more than offset by the increase in grain yields due to the above-mentioned fertility factors relating to forage. Such a relation between two crops is complementary, in contrast to the competitive relation that exists between grain crops. Of course, sooner or later, the grain and forage acres in a rotation compete with each other and more forage can only be grown from a given area at the expense of grain. The yield increase effect due to forage is more than offset by the fall in grain acres due to more acres in forage. Total grain production from a given area begins to fall as forage output increases.

Results from experiments on rotation relationships seem only to be available from America. The following is a shortened version of one such experiment [2]:

Cropping System	Per cent in Hay	TOTAL PRODUCTION	
		Grain	Hay
(1) C	0	180,320	—
(2) C-C-O-Cl	25	217,360	85,000
(3) C-O-Cl	33	182,333	132,660

(C=Maize; O=Oats; Cl=Clover)

The above results are typical of those deriving from similar experiments. It will be seen that the introduction of 25 per cent forage in the second rotation has a complementary effect

on total grain production when compared with the first rotation of continuous maize. However, when a greater acreage of forage is introduced in the third rotation, it becomes competitive with grain in the sense that a greater acreage of hay reduces total grain production. Most soils seem to give rise to this kind of relation.

In designing a rotation to achieve maximum returns it can be seen that the forage acreage must be sufficient to exhaust the complementary relationship and thus achieve maximum grain output. Until this is reached it will pay to increase the forage acreage whatever the level of crop prices. Indeed, if the price of forage is zero its production is still profitable. Normally, however, forage has a sale price or it can be profitably utilised through livestock, in which case a net gain accrues to both crops and livestock.

Lacking information on rotation relationships in Kenya, no precise statements can be made on optimum economic land use. It appears probable, however, that the discussion above has some relevance, at any rate to the Uasin Gishu area. If the crop/grass ratio is

still within the complementary range, which is likely, then no elaborate proof is needed to indicate the economic advantage of increasing the pasture acreage. From the foregoing it will be seen that by increasing his leys the farmer will actually get something, in the form of increased grain yields, for nothing. Whether he decides to use his extra fodder or not, total grain output will increase up to a point. The farmer should not be led into a false sense of security because he has been able to maintain yields over a period. This has been for him an expensive business as a comparison between the cost of fertilisers used now and five years ago will show. Unless there is some improvement in the cropping pattern, yields will only be maintained by a greater use of fertiliser. This will be increasingly costly in face of grain prices which are unlikely to move in sympathy. It is surely cheaper to maintain yields, as far as possible, by the use of complementary forage.

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THE AFRICAN CULTIVATOR

To build a house without foundations is courting disaster. In the same way it is waste of effort to attempt to introduce improved methods of agriculture without having some peg to hang them on. No peasant cultivator can be expected to assimilate an idea which is totally unrelated to anything else in his experience, and yet many extension officers frequently expect this to happen. Revolutionary methods may occasionally succeed, but evolution is the safer bet in the long run.

The African cultivator is not a fool. The older men have been working the land for many years and they have acquired valuable experience which is so often overlooked or pooh-poohed. Some of their beliefs are pure fantasy, but others have a basis of solid fact which cannot be neglected with impunity. Extension officers come and go very fre-

quently, but the man on the land remains, outwardly complying with some fanciful whim culled from a temperate climate, inwardly laughing to himself in the knowledge that it cannot work in practice. There are for instance Africans in the Songea district who have been growing tobacco for nearly 20 years; it would be folly not to profit from their experience when a change of policy is contemplated.

In some parts of East Africa this sort of information has been collected and is written up in the district books: let us use it and not leave it to sink into oblivion. Where no records exist, the collection of such data should have a high priority, but discretion must be used: it is dangerous to record a belief without obtaining some evidence as to its correctness.

J. R. P. SOPER.

SOME OBSERVATIONS ON THE GERMINATION AND GRADING OF CASHEW NUTS

By D. J. Turner, Tanganyika Agricultural Corporation, Nachingwea

(Received for publication on 3rd May, 1956)

Cashew nuts are now a crop of considerable importance to the Southern Province of Tanganyika. The acreage under it is increasing rapidly, both on African holdings and on an estate scale. In the Nachingwea area, for example, some 1,800 acres of cashew have been recently planted on the Tanganyika Agricultural Corporation's farms.

Cashew seedlings do not transplant well and plantations of any size are almost always established by sowing the nuts *in situ*. The germination of the nuts is, however, often poor and rather slow. Selection of seed according to size or appearance seems to be of little value in improving germination. Shrivelled, discoloured nuts often germinate as well as clean, sound-looking seed. In the field the first seedlings may appear about two weeks after planting, but many nuts take much longer. In a new plantation at Nachingwea some seedlings were still appearing eight weeks after the nuts had been sown.

The critical stage in the establishment of a new plantation is generally the first dry season after planting. Unless the young trees have made fair growth before the end of the rains, mortality during the dry months is likely to be heavy. Seedlings should therefore be established as soon as possible after the start of the rainy season. Where replanting is necessary or where germination is very slow, the chances of survival may be reduced. The object of the work described in the first part of this paper was to find a simple method of selecting viable nuts with the capacity for rapid germination, for use as seed.

It is fairly generally assumed by farmers and others that plump, well-filled seeds are more likely to germinate and give rise to healthy seedlings than are small or shrunken seeds. Thus seed weight, or size, or density are often quoted as measures of seed quality, although there is sometimes confusion between these three types of statistic. This assumption has often, although not always, been supported by experimental evidence. For example, Laycock (1951) has shown that tea seed of high specific gravity germinates better than seed of low specific gravity. He was unable to show any significant differences in the germination of

large and small seeds; but after 18 months' growth it was found that the large seed had produced bigger seedlings than had the small seed.

Turning again to the germinating ability of cashew nuts, it has already been mentioned that this character does not appear to be directly related to the size of the seed. Clegg (1954) has, however, shown that a large proportion of the nuts that float in water have small or defective kernels. Nuts of greater density, which sank in water, gave a significantly higher weight of kernels after roasting. These observations and the work carried out by Laycock (1951) suggested that grading according to specific gravity might possibly be a useful method of seed selection in cashew nuts. In the first part of this paper some experiments carried out with this method of grading are described.

A study has also been made of the relationship of density to output of kernels after roasting, with the object of working out a simple system of grading cashew nuts for sale. Complaints regarding the quality of cashew nuts are frequently heard from buyers. In some consignments it has been found that a large proportion of nuts are empty or contain only very small kernels. At present much of the Tanganyika cashew crop is exported to India; and in view of the present high freight charges grading before shipment appears to be desirable. Good quality is also of particular importance, because a large part of the cost of producing roasted kernels is due to the expensive operation of cracking the shells by hand. Where there is a high proportion of small or defective kernels the process may be uneconomic.

As has already been mentioned, Clegg (1954) has shown that nuts that float in water give a much lower output of sound kernels when roasted than do nuts which sink. It seemed probable that, in general, nuts of higher specific gravity would be better filled and therefore give a higher kernel output when roasted than would nuts of low density. The second part of this paper records trials carried out to test this hypothesis. It was thought that a system of grading based on the specific gravity of the nuts might give samples of relatively uniform quality.

MATERIALS AND METHODS

The cashew nuts used in these experiments were part of a random sample drawn from about 1,000 lb. of ordinary unselected nuts harvested at Namanga Farm, Nachingwea, in November 1955. The work described in this paper was commenced about three months after harvesting; the nuts were therefore slightly older than would be the case for seed planted in the field at a normal date.

The nuts were cleaned by hand to remove pieces of adhering cashew apple and other rubbish. Preliminary tests had shown that the specific gravity of individual nuts ranged from about 0.960 to 1.105, and it was therefore decided to grade the nuts into five density classes:

Below 1.000, 1.000–1.025, 1.025–1.050, 1.050–1.075, greater than 1.075.

Solutions of specific gravity 1.000, 1.025, 1.050 and 1.075 were made up with tap water and ordinary cane sugar, using a hydrometer capable of reading to specific gravities of 0.001. The nuts were graded into density classes by placing them in each solution for five minutes. Those that floated and those that sank were taken to be of lower and higher densities respectively than the solution used. After a thorough washing the nuts were dried in the sun and each grade weighed.

Rather unexpectedly it was found that almost all the very large nuts in the sample came into the lower density classes. A rough assessment of the proportion of very large nuts in each class was made by weighing separately those that did not pass a sieve with $\frac{3}{4}$ -in. by $\frac{3}{4}$ -in. rectangular perforations. After weighing, these large nuts were returned to the density classes from which they had been drawn and thoroughly mixed with the remaining nuts.

The germination of nuts within the various density classes was tested as follows: Four samples, each of 100 nuts, were drawn at random from each of the five density classes. After weighing the samples were dusted with Fernasan (an organic seed dressing), placed on moist sand in a wooden seed box, and covered with a pad of blotting paper. The seed boxes were kept in a pile in the corner of the laboratory and watered daily, the position of each box in the pile being allocated at random and changed at each watering. The boxes were examined daily and any germinated nuts were counted and removed. At approximately weekly intervals the sand in the boxes was

changed. In view of the size of the boxes accurate control of temperature and humidity conditions was impracticable.

Assessment of shelling percentage was made using the following procedure: Four more samples of 100 nuts were taken at random from each of the five density classes. After weighing, the samples were roasted, using a method intended to simulate that used on a large scale in cashew factories. The nuts were immersed in hot vegetable oil contained in a shallow iron vessel which was heated by a Primus stove. The vessel was covered with a sheet of metal and the nuts roasted until the shells were a dark brown colour. A good deal of oil was obviously removed from the nuts during this process, which usually took about 10 minutes. Accurate temperature control was unfortunately not possible with the equipment available. After roasting, each batch of nuts was shaken with vermiculite, to absorb the oil adhering to the shells, and weighed. The kernels were removed by cracking the shells and the weight of kernel produced by each sample was taken.

Finally the kernels were sorted into two grades. The first grade consisted of sound kernels free from discoloration, while kernels with brown markings or other obvious defects were classed as second grade. Kernels that were accidentally broken in shelling but were free from discoloration were placed in the first grade.

RESULTS AND DISCUSSION

In Table I the weights of cleaned, unshelled nuts forming each density grade are shown as percentages of the original unselected sample. Also shown in this table are the weights of very large nuts in each grade which failed to pass the $\frac{3}{4}$ -in. by $\frac{3}{4}$ -in. sieve. With other samples of cashew nuts the relative proportions of each grade may, of course, be very different; but it will be observed that all the very large nuts were of comparatively low density. This point will be referred to later.

Table II shows the average weights of 100 raw, unshelled nuts drawn at random from each density grade. In all cases the weight shown is the mean of eight observations. In this particular sample, nuts of low or high density have a significantly lower weight per 100 seed than have nuts of intermediate specific gravity. Nuts forming the highest density grade (S.G. greater than 1.075) are therefore likely to be relatively small in size. It does not of course

necessarily follow that these statements are of general application. Further trials with samples of cashew nuts from other sources might be of interest.

TABLE I—WEIGHTS OF CLEANED CASHEW NUTS IN EACH DENSITY GRADE

Specific Gravity	(a) Total Wt. of nuts (kg.)	(b) (a) as % of total unselected sample	(c) Wt. of nuts failing to pass $\frac{3}{4} \times \frac{3}{4}$ sieve (kg.)	(d) (c) as % of total unselected sample
Less than 1.000 ..	3.13	9.30	0.49	1.46
1.000–1.025 ..	2.95	8.77	0.09	0.27
1.025–1.050 ..	9.35	27.79	—	—
1.050–1.075 ..	12.94	38.47	—	—
Greater than 1.075 ..	5.27	15.67	—	—
Original unselected sample	33.64	100.00	0.58	1.73

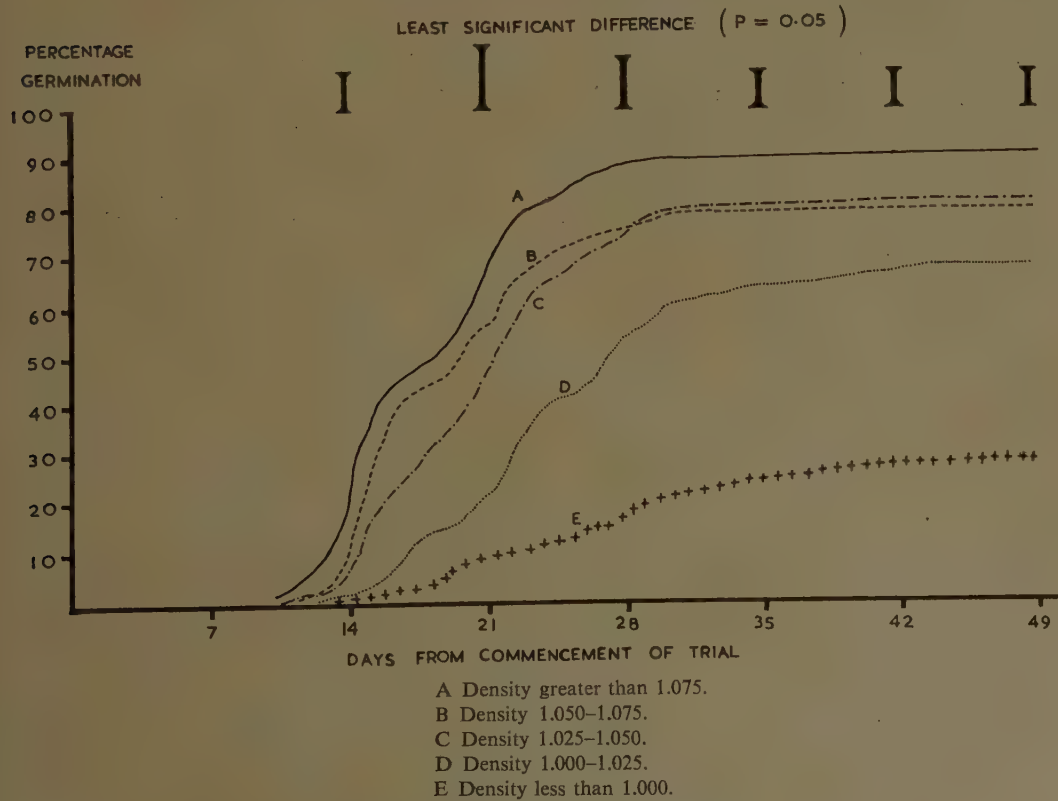
TABLE II—AVERAGE WEIGHT OF 100 NUTS FROM EACH DENSITY GRADE

Specific Gravity	Mean Weight of 100 seed
Less than 1.000	360.6 gm.
1.000–1.025	387.4 gm.
1.025–1.050	378.5 gm.
1.050–1.075	379.6 gm.
Greater than 1.075 ..	369.4 gm.
Least significant difference	19.9 gm. (P=0.05) 17.2 gm. (P=0.01)

Germination.—The course of germination of samples of nuts from the five density grades is shown graphically in Figure I. Each curve represents the mean behaviour of four germination tests. The somewhat irregular form of the germination curves may be partly due to lack of adequate moisture and temperature control.

It appears that cashew nuts of different specific gravity vary considerably, both with

FIG. I.—GERMINATION OF CASHEW NUTS GRADED ACCORDING TO DENSITY



Least significant differences, at 5 per cent probability level are shown at 14, 21, 28, 35, 42, 49 days.

regard to speed of germination and total viability. In general, nuts of greater density germinated more quickly than nuts of lower density. Thus, 50 per cent of the viable nuts in the lowest density grade had germinated 26 days after the commencement of the trial. With grades of higher specific gravity—(1.000–1.025), (1.025–1.050), (1.050–1.075), (greater than 1.075)—germination of 50 per cent of viable seed had occurred after only 23, 20, 17 and 16 days respectively. As already pointed out, speed of germination may be an important factor in establishing cashew in areas subject to uncertain rainfall.

The total viability of nuts was also generally greater with seed of higher density. Thus nuts of specific gravity greater than 1.075 germinated significantly better than all other grades tested. Seed of specific gravity (1.000–1.025) was better than seed of specific gravity less than 1.000. The total germination of nuts from the (1.025–1.050) and (1.050–1.075) grades was however almost the same, although as mentioned above seed of the higher density grade germinated more quickly.

It is clear that, in this particular sample, selection of nuts of high specific gravity would be of value for seed purposes. Further trials with cashew nuts from other sources would seem desirable. An investigation of the relationship between seed density and size of the resultant seedlings at various intervals of time after planting would also be of interest. It is hoped to carry out such a trial at Nachingwea in the 1956/57 planting season.

An examination of cashew nuts from low and high specific-gravity grades has shown that with the former grades there are considerable air spaces between the seed proper and shell and between the two cotyledons. With nuts of higher specific gravity the air spaces are relatively smaller. It would of course be expected that nuts of very low density with very small or defective kernels would germinate poorly; but it is not clear why there should be such marked differences in the germination behaviour of grades between which the density difference is relatively small.

As has been mentioned above, all the very large nuts in the sample came into the two lowest density grades. The number of nuts in the original sample failing to pass the $\frac{3}{4}$ -in. by $\frac{1}{4}$ -in. sieve was not large enough for separate germination tests, but no obvious differences were observed in the behaviour of large nuts and normal-sized nuts of the same specific

gravity. Both large nuts and normal nuts of the same density grade germinated slowly and poorly. It has been observed that immature nuts on the tree are usually larger than ripe nuts: during the process of ripening considerable shrinkage takes place. It is suggested therefore that the very large nuts in the sample may be the result of arrested development due to premature harvesting or perhaps insect damage. Whatever the reason for their existence, it is clear that very large nuts are not likely to be suitable for seed purposes.

Output of Roasted Kernels.—The output of roasted kernels from samples of 100 cashew nuts taken at random from each density grade is shown in Table III. Each figure is the mean of four determinations.

Nuts of the lowest density class lost more weight during roasting than did nuts of higher specific gravity. The difference in this respect between the density grades (less than 1.000) and (greater than 1.075) is highly significant.

The higher density grades gave a greater output of kernels after roasting than did nuts of lower specific gravity. Thus the total weights of kernels recovered from 100 nuts of density grades (1.050–1.075) and (greater than 1.075) were significantly better than the weights obtained from 100 nuts of any other grade. Nuts of specific gravity (1.025–1.050) were superior to those of the (1.000–1.025) density class, which were in turn significantly better than the (less than 1.000) grade. It will be noticed that there was no significant difference in the absolute weights of kernels recovered from 100 nuts of grades (1.050–1.075) and (greater than 1.075). When, however, kernel output is expressed as shelling percentage on a weight for weight basis (Table III, col. 6) it appears that the higher density grade is superior. This difference is of course due to the relatively lower seed weight of this grade.

The proportion of defective kernels decreased steadily with increase in seed density. Thus nuts of specific gravity under 1.000 gave approximately 40 per cent by weight of defective kernels. In the (1.000–1.025) specific gravity grade about 25 per cent of kernels were discoloured, while in grades (1.025–1.050), (1.050–1.075) and (greater than 1.075) the proportions were approximately 4 per cent, 2 per cent and 1 per cent respectively. In Table III, col. 7, the output of sound kernels is shown as a percentage of the weight of the unshelled nuts before roasting.

TABLE III—WEIGHTS OF ROASTED KERNELS OBTAINED FROM CASHEW NUTS OF VARIOUS DENSITY GRADES

Means of 4 Determinations

Specific Gravity	1 Av. wt. of 100 raw nuts (gm.)	2 Av. wt. of 100 nuts after roasting (gm.)	3 % loss of wt. during roasting	4 Total wt. of kernels recovered (gm.)	5 Wt. of sound kernels recovered (gm.)	6 Total Shelling percentage	7 Shelling percentage (sound kernels only)
Less than 1.000.. ..	363.9	265.2	27.1	64.9	37.8	17.8	10.4
1.000-1.025	393.5	295.1	25.0	105.1	88.5	26.7	22.5
1.025-1.050	375.8	280.3	25.4	105.9	102.0	28.2	27.1
1.050-1.075	386.7	295.1	23.7	113.7	111.8	29.4	28.9
Greater than 1.075	363.8	278.6	23.4	111.2	110.0	30.6	30.2
Least significant difference:							
(P=0.05)	19.8	19.9	2.6	4.2	5.8	0.8	1.3
(P=0.01)	27.4	27.5	3.5	5.8	8.0	1.1	1.8

It appears that selection according to density may be a useful method of preparing uniform grades for sale to processors. Differences in kernel output between the three highest density grades (1.025-1.050, 1.050-1.075, greater than 1.075) are relatively small but quite significant. A large part of the cost of producing roasted cashew kernels is due to expenditure on cracking the shells by hand. A high rate of kernel output per 100 nuts, or per pound of raw cashew nuts, is therefore of more importance than might appear to be the case at first sight.

It is emphasised that the work reported in this paper was carried out with cashew nuts from one source only. Further experimentation with nuts from other localities that have been kept in storage for different periods would probably be necessary before grading according to density could be generally recommended. In the present sample the specific gravity of individual nuts ranged from about 0.960 to 1.105. With other samples the range of specific gravity and the relationship of kernel output to density might be very different.

Finally it should perhaps be pointed out that any process or machine capable of sorting material according to specific gravity might be suitable for grading cashew nuts. Sugar solutions are inconvenient and unpleasant to work with and deteriorate after a short time. Solutions of common salt would probably be preferable and are a fairly obvious alternative.

SUMMARY

A sample of unselected cashew nuts harvested in 1955 at Namanga Farm, Nachingwea, was separated into five density grades, using

sugar solutions of different specific gravities. A study was made of the relationship of density to germination behaviour, and output of kernels after roasting. The results may be summarised as follows:

- (1) Nuts of greater density germinated more quickly than nuts of lower density.
- (2) Total viability was generally greater with grades of higher specific gravity.
- (3) Very large nuts were all of relatively low density. Their viability and rate of germination were poor.
- (4) Output of roasted kernels from grades of higher density was significantly better than from grades of lower density.
- (5) The percentage of sound kernels progressively increased with increasing specific gravity.

The results suggest that a system of grading according to density may be of value in seed selection, and in preparing grades of uniform quality for sale.

ACKNOWLEDGMENT

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INDIGENOUS CLOVERS OF KENYA

By A. V. Bogdan, F.L.S., The Grassland Research Station,

Department of Agriculture, Kitale, Kenya

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In the flora of Kenya, among the naturally occurring leguminous grazing plants, clovers are fairly important in the highlands at altitudes over 6,000 ft., and it is possible that several of them will be introduced into cultivation in the near future as components of leys. It is desirable, therefore, that information on Kenya clovers, including the means for their identification, should be available to those interested in agriculture, and especially in grassland problems.

The information on the taxonomy of the indigenous clovers of Kenya has been out of date until recently and scattered in numerous botanical publications. In 1952 the African species of clover were critically revised by J. B. Gillett in his article "The Genus *Trifolium* in Southern Arabia and in Africa South of the Sahara", in *Kew Bulletin*, 1952. The information on the grazing value of Kenya clovers and on the possibility of their introduction into cultivation was also scattered in various publications, mostly in the form of occasional observations, although an attempt to summarise the existing knowledge was made in "Important Grassland Plants of Kenya" by D. C. Edwards and A. V. Bogdan. The present account aims to help agricultural officers and farmers who are interested in distinguishing species and varieties of the indigenous clovers of Kenya, and also to draw attention to the more useful species suitable for cultivation.

The taxonomic part of this publication is based mainly on Gillett's revision, while the part dealing with introduction into cultivation is based on work recently done at the Kitale Grassland Research Station. This station is situated in Western Kenya at 6,200 ft. altitude. The rainfall is 40-45 in. per annum, falling mostly in one long rainy season lasting from April to September, with less rain in October-November and a dry period in January-March.

The *Trifolium* species are annual or perennial herbaceous plants, usually with trifoliate leaves, on which the stipules are united with the leaf-stalk. The stamen-tube which is formed by nine joined stamens—a common

feature in *Papilionaceæ*—in *Trifolium* is also joined with the keel. *Trifolium* is predominantly a genus of temperate countries of the northern hemisphere and of the Mediterranean area. Only a comparatively few species occur in Africa, 15 of them in Kenya.

KEY TO SPECIES

1. Leaves in the middle of the stem with very short stalks appearing as though they are borne on the stipules (Figs. 1-5) .. 2
- 1a. Leaves in the middle of the stem with conspicuous stalks (Figs. 6-14) .. 5
2. Leaflets small, under 8 mm. long, wedge-shaped, broad and blunt at the apex (Figs. 4 and 5); a low creeping perennial with semi-globose flower heads .. (1) *T. cryptopodium*.
- 2a. Leaflets larger, usually over 8 mm. long, narrowing to the apex; perennials or annuals .. 3
3. Free parts of the stipules awl-shaped or filiform from a short triangular base (Fig. 2); flower heads globose .. (5) *T. simense*.
- 3a. Free parts of the stipules triangular or lanceolate; flower heads oblong or cylindrical, except when very young .. 4
4. Leaflets in the middle of the stem under 15 mm. long (Fig. 1); annual .. (2) *T. usambarense*.
- 4a. Leaflets in the middle of the stem usually well over 15 mm. long (Fig. 3); perennial .. (3) *T. polystachyum*.
5. Flowers white or cream-coloured, with the standard often tinged with purple or pink; pedicels and flowers markedly nodding after flowering; creeping perennials .. 6
- 5a. Flowers purple or violet, not nodding after flowering .. 7
6. Leaf stalk in the middle part of the stem long, much exceeding the stipules (Figs. 10 and 11) .. (8) *T. semipilosum*.
- 6a. Leaf stalk in the middle part of the stem short, less than the length of the stipules (Fig. 14); on the upper part of the stem leaf stalk wanting .. (4) *T. cheranganiense*.
7. Flowers 1 to 5 on axillary stalks (peduncles) or stalkless in the leaf axils .. 8
- 7a. Flowers more numerous, in dense heads .. 10
8. Perennial with short prostrate stems; pods 2-4 seeded .. (7) *T. acaule*.
- 8a. Annuals; pods 4-9 seeded .. 9

9. Flowers stalked, 1-5 on a peduncle ..
(12) *T. multinerve*.
- 9a. Flowers without apparent stalks, single or
paired in the leaf axils
(13) *T. elgonense*.
10. Involucre composed of enlarged bracts at
the base of the flower head; leaflets long,
narrowly lanceolate 11
- 10a. Involucre inconspicuous, the bracts being
very small and inconspicuous; leaflets
lanceolate or ovate 12
11. Calyx teeth 6-7 mm. long, longer than the
corolla
(14) *T. lugardii*.
- 11a. Calyx teeth 2-4 mm. long, shorter than
the corolla
(15) *T. steudneri*.
12. Flower heads at the flowering stage
20-25 mm. in diameter, flowers white or
purplish-violet; perennial
(16) *T. burchellianum*.
- 12a. Flower heads less than 20 mm. in diameter,
flowers purple 13
13. Flowers numerous, normally over 15 in one
flower head; calyx under 6 mm. long .. 14
- 13a. Flowers not numerous, normally less than
15 in one flower head; calyx 7-9 mm. long
(11) *T. tembense*.
14. Leaflets rarely emarginate, usually strongly
toothed; calyx teeth abruptly narrowed at
the base; standard 3-8 mm. long ..
(9) *T. rueppellianum*.
- 14a. Leaflets usually emarginate with numerous
small teeth; calyx teeth gradually narrow-
ing from the base; standard 3-4 mm. long
(10) *T. baccarinii*.

1. *Trifolium cryptopodium* Steud. ex A. Rich.

A low-growing perennial with creeping stems densely covered with small leaves. Flower heads numerous, small, semi-globose, dense. Flowers violet or purplish-violet. Occurs mostly at very high altitudes—from 10,000 ft. to 14,000 ft. in the alpine zone. At lower altitudes, down to 7,000 ft., it occurs occasionally near water in open, usually rocky places. In the alpine zone, *T. cryptopodium* often covers a considerable portion of the soil surface, creeping amongst grasses. Planted from roots at the Kitale Grassland Station, this species did well during the rainy season, producing a dense cover of creeping shoots and numerous flower heads, but died out with the onset of the dry weather. *T. cryptopodium* seems to be unsuitable for cultivation because of its low growth and high moisture require-

ments. In its natural environment, in short grass at very high altitudes, it is occasionally grazed, and may be a useful component in such pastures.

2. *Trifolium usambarense* Taub.

An annual 6 in. to 2 ft. high. Stems numerous, thin, prostrate to semi-erect. Leaves numerous with rather small elliptic or oblong leaflets which are borne on the part of the stalk united with the stipules (Fig. 1). Flower-heads numerous, small, oblong, short when young and becoming longer with age. Flowers purple.

Occurs in Kenya at altitudes from 6,000 ft. to 10,000 ft., but in the Usambara Mountains in Tanganyika is found as low as 3,000 ft., and Gillett states that of all the tropical species of *Trifolium*, *T. usambarense* occurs at the lowest altitudes. Seasonal swamps, swamp-edges, and swampy stream banks are the usual habitats of this species and in such places it is often abundant and forms a considerable portion of the herbage. The plant is reputed to be palatable to cattle.

At the Kitale Grassland Research Station, *T. usambarense* was tried under cultivation on a small scale on swampy ground. It germinated well and formed a very dense leafy herbage 6-9 in. high, with numerous creeping and ascending stems which rooted freely from the nodes. *T. usambarense* grows more slowly than *T. rueppellianum* or *T. tembense* but lasts longer and remained green in the first half of the dry season.

3. *Trifolium polystachyum* Fres.

Perennial with prostrate, or semi-prostrate, rather thick stems. Leaves fairly numerous, with membranous stipules. Petiole with no free stalk and the leaflets are borne on the part united with the stipules (Fig. 3). Leaflets lanceolate to narrow lanceolate, long. Flowers purple, in oblong to cylindrical heads which are $\frac{1}{2}$ -1 $\frac{1}{2}$ in. long and $\frac{1}{4}$ in. wide. Of the three varieties known in Africa only var. *polystachyum* Fres. has been recorded from Kenya. It occurs in the Kitale and Eldoret areas on swampy ground, and is fairly common in a large swamp a few miles north of Kitale. *T. polystachyum* may be found suitable for cultivation in seasonal swamps, but has not yet been under trial.

4. *Trifolium cheranganiense* Gillett

Perennial with densely hairy, prostrate and creeping stems rooting from the nodes. Unlike

T. semipilosum and *T. repens*, this species forms no new plants from the nodes. Leaves numerous, small. Stipules short, with the free part as long as the united part, or longer. Free part of leaf stalk short to very short on the middle and lower leaves (Fig. 14), and wanting on the upper leaves. Leaflets ovate to lanceolate, about $\frac{1}{2}$ in. long. Flower heads semi-globose, with numerous flowers. Flowers cream-coloured, on pedicels 2-5 mm. long. After flowering the pedicels and flowers bend downwards. Occurs on the Cherangani Hills at altitudes of 7,500 ft.-10,000 ft., and is common in short grass at about 8,000 ft. It is palatable to grazing animals and is of importance for grazing in places where it occurs in large quantities. Attempts to cultivate this clover at the Kitale Grassland Station showed that it lasted for about two years, but did not produce heavily. It is easily established from seed but develops slowly, requires much weeding and dries quickly at the beginning of the dry season.

5. *Trifolium simense* Fres.

Perennial with semi-erect to erect stems, often from a prostrate base. Leaves not numerous. Stipules membranous, with the free parts very narrow, filiform from a triangular base (Fig. 2). Free stalk with no petiole and the leaflets are borne on the part united with the stipules. Leaflets vary in shape and size but are mostly very narrow and long. Flowers purple, in dense globose heads which are $\frac{1}{2}$ - $\frac{3}{4}$ in. in diameter. Common at altitudes of 7,000-9,000 ft., mostly on swampy ground. It is particularly frequent in swamps near Londiani. This clover is of low palatability, probably because of its hard, wiry stems and a low proportion of leaf in the herbage.

6. *Trifolium burchellianum* Ser.

Perennial which varies in habit from low plants, with the stems creeping and rooting from nodes, to almost erect, tall plants. Leaves numerous, with short stipules and long free stalks (Figs. 8 and 9). Flowers purplish-violet or violet in large semi-globose heads $\frac{3}{4}$ -1 $\frac{1}{4}$ in. in diameter. Two varieties of this species occur in Kenya: var. *johnstonii* (Oliv.) Gillett (= *T. johnstonii* Oliv.) and var. *oblongum* Gillett. Var. *johnstonii* is a low creeping form with obovate leaflets; it occurs in occasional colonies at high altitudes. Var. *oblongum* forms large, sometimes tall plants with oblong leaflets and usually with larger flower heads. This variety is less common and has been

recorded only from the Cherangani, Elgon and Mau Narok areas. It occurs in tall grass or in bush, also at high altitudes. Both varieties of *T. burchellianum* are valuable grazing plants.

Attempts to cultivate *T. burchellianum* have so far not been successful, mainly because of its poor seeding qualities. Seeds are only sparsely produced and germinate slowly and unevenly. Plots of var. *johnstonii* at the Kitale Grassland Station flowered fairly well and produced some well-formed seeds, but only in the second year of growth. Var. *oblongum* has seldom formed seed under cultivation. The wild plants from the Cherangani Hills were also mostly sterile. It may be possible to overcome the difficulty of seed-production by growing these clovers at a higher altitude. For example, seed of var. *johnstonii* has been produced on a small scale at about 8,000 ft. on a farm near Mau Summit. Under cultivation *T. burchellianum* develops slowly, but eventually becomes more vigorous than *T. semipilosum*.

7. *Trifolium acaule* Steud. ex A. Rich.

Low perennial with short prostrate stems. Flower heads with 1-5 flowers on short common stalks (peduncles) from the leaf-axils. Occurs on the slopes of Mount Elgon from 10,000 ft. to the summit (14,000 ft.) and is of no importance for grazing.

8. *Trifolium semipilosum* Fres. (In D. C. Edwards' publications the name *T. johnstonii* was used to denote this species, as until recently correct identification of East African clovers was difficult.)

Prostrate perennial resembling *T. repens*, European White Clover. Stems creeping and rooting from the nodes. Short vertical stems often arise from the rooting nodes. Leaves numerous, with long stalks and short stipules (Figs. 10 and 11). Leaflets vary considerably in size, shape, hairiness and even in colour; in some forms purple or white spots are found on the leaflets. Flower heads on long stalks (peduncles). Flowers white, cream-coloured, or occasionally pink or salmon-coloured, with the standard often tinged with purple. Pedicels are comparatively long, and after flowering they bend downwards in the same way as in the European white clover. The numerous forms of *T. semipilosum* which occur in Kenya are grouped into four varieties:

var. *semipilosum* Fres., with one half of the lower surface of the leaflets markedly hairy.

var. *glabrescens* Gillett, with the leaflets almost hairless and only a few hairs are found on one half of the lower surface. This variety resembles *T. repens* more than the other varieties.

var. *microphyllum* Chiov., a high altitude variety with very small leaflets which are under 4 mm. long.

var. *kilimanjaricum* E. G. Baker, with elliptic or oblong leaflets which are twice as long as broad (Fig. 10). This is also a high altitude variety.

T. semipilosum is widely distributed in Kenya from about 5,500 ft. to over 10,000 ft. It is very common in the highlands and is often abundant in grassland where the dominant grass is *Pennisetum clandestinum* (Kikuyu grass). D. C. Edwards (1940) found that in grazed Kikuyu grass pastures the proportion of *T. semipilosum* in the herbage was high and varied from 5 per cent to 15 per cent. If the grazing was discontinued the clover disappeared rapidly. In his experiments the same effect was produced by mowing and, while a high proportion of *T. semipilosum* was observed in the mown plots, the proportion was very low or almost nil in plots where the Kikuyu grass was allowed to grow uncut. After the mowing was reintroduced, the clover appeared again and took its normal place in the herbage. Under good soil conditions *T. semipilosum* may appear in large quantities even in the comparatively dry parts of Kenya, where it grows in association with Rhodes grass (*Chloris gayana*) or Star grass (*Cynodon dactylon*), as has been observed in the Nakuru-Rongai area and also at Naivasha.

T. semipilosum has been fairly well grazed in grass-clover mixtures at the Kitale Grassland Station, but there are also reports that its palatability is low. Apparently cattle have to get used to it before they will eat it in large quantities. Cases of bloat have also been recorded. The grazing of pure and high clover swards should be avoided. Attempts to cultivate *T. semipilosum* were first made by D. C. Edwards at Kabete and he selected four types which were brought to Kitale Grassland Station for large-scale experiments. The type under cultivation belongs to var. *glabrescens*. It has so far been found that under Kitale conditions *T. semipilosum* can easily be grown from seed, either in pure stands or mixed with grass. In the higher rainfall areas this clover will persist indefinitely in grazing mixtures

with such species as Rhodes, Molasses and Star grass, and, where conditions favour its growth, care must be exercised to prevent it from becoming too aggressive. If the pasture is kept too short by intensive grazing there is often a tendency for the clover to suppress the grass or even to kill it out entirely.

Extensive work on this clover, including a study of various grass-clover mixtures, is in progress at the Kitale Grassland Station. *T. semipilosum* is a good seed-producer and at the Kitale Grassland Station it has been harvested successfully by a combine harvester. Yields up to 200 lb. per acre of seed have been obtained in this way, and much more by hand harvesting. The pods of *T. semipilosum* do not shatter easily and only a small proportion of seed is lost when harvested mechanically.

9. *T. rueppellianum* Fres.

An annual with much-branched, semi-prostrate to erect stems which vary in height from a few inches to 2 ft. Leaves numerous. Petioles vary in length from short to very long. Leaflets obovate to lanceolate (Figs. 12-13). Flower heads numerous, semi-globose. Flowers purple. Three varieties have been found in Kenya:

var. *rueppellianum* Fres. Standard longer than calyx. Leaflets rounded or truncate at the apex.

var. *lanceolatum* Gillett. Standard shorter than calyx. Leaflets lanceolate, pointed.

var. *preussii* Gillett. Standard shorter than calyx. Leaflets rounded or truncate at the apex.

T. rueppellianum is widely distributed in Kenya from just over 5,000 ft. to almost 10,000 ft. At lower altitudes it occurs on river banks. At higher altitudes it is common in seasonal swamps and also on dry ground amongst grass in the areas of high rainfall. This clover is fairly well grazed by cattle.

At the Kitale Grassland Station *T. rueppellianum* has been tried under cultivation with success. It can easily be grown from seed. In mixtures with perennial grasses it re-seeds easily and under suitable management appears to persist indefinitely. When grown in pure stand for seed production it makes very vigorous growth and there is a tendency to lodge. This may be overcome to some extent by removing the first flush for hay or silage. Seed yields of about 200 lb. to the acre have

LEAVES OF SOME OF KENYA CLOVERS (DIAGRAMMATICAL, ACTUAL SIZE)

1. *Trifolium usambarense*2. *T. simense*3. *T. polystachyum*4 and 5. *T. cryptopodium*6. *T. tembense*7. *T. steudneri*8. *T. burchellianum* var. *johnstonii*9. *T. burchellianum* var. *oblongum*10. *T. semipilosum* var. *kilimanjaricum*11. *T. semipilosum* var. *glabrescens*12. *T. rueppellianum* var. *lanceolatum*13. *T. rueppellianum* var. *rueppellianum*14. *T. cheranganiense*

been obtained by direct combining. Pods of this clover shatter easily and there can be considerable loss of seed during harvesting. A few forms of *T. rueppellianum* are under trial; most of them belong to var. *rueppellianum* which is usually more vigorous than the other two varieties. In cultivated plots this species yielded 20 tons per acre of green material per annum.

10. *Trifolium baccarinii* Chiov.

An annual with much branched stems and purple flowers. This species resembles smaller varieties of *T. rueppellianum*. It occurs occasionally in western Kenya.

11. *Trifolium tembense* Fres.

Annual 6-24 in. high with semi-prostrate or erect stems. Leaves with short to long petioles and rather large ovate or elliptic leaflets (Fig. 6). Flower heads with not numerous, normally 5-15, purple flowers.

This clover occurs frequently from 7,000 to 10,000 ft. in seasonal swamps, on stream banks and at the edges of permanent swamps. It is very common and frequent in the Ol Kalou area near Lake Ol Bolossat.

T. tembense is less leafy and seems to be less palatable than *T. rueppellianum*. At Kitale it has been cultivated only on a small scale. It grows very fast from seed, but is shorter-lived than *T. rueppellianum*.

12. *Trifolium multinerve* (Hochst.) A. Rich.

A small annual with prostrate or semi-erect stems. Leaves with small, narrow leaflets. Flowers purple, 1 to 5 on a common stalk which is about as long as the leaves. Occurs occasionally from altitudes of 7,000 ft. up to 10,000 ft. This clover is very small and is of no value for grazing purposes.

13. *Trifolium elgonense* Gillett

A small annual with prostrate stems. Leaves with small obovate leaflets. Flowers purple, single or paired in the leaf-axils. Occurs in the alpine zone of Mt. Elgon and is also of no value for grazing purposes.

14. *Trifolium lugardii* Bullock.

An annual 1-2½ ft. in height with erect, sparingly branched stems. Leaves with long stalks and long narrow leaflets. Flower heads large, not numerous. Flowers purple; calyx with long teeth which are longer than the corolla. Occurs in the area of Mt. Elgon from 5,800 to 8,000 ft. Its grazing value is unknown.

15. *Trifolium steudneri* Schweinf.

An annual 9 in. to 2 ft. high. Stems erect, much branched, with the branches mostly erect. Leaves with long stalks and long, narrow leaflets (Fig. 7). Flower heads globose or semi-globose, on long peduncles, with an involucre of enlarged bracts at the base of the heads. Flowers purple; calyx with short teeth which are shorter than the corolla. The plant resembles *T. lugardii* but seems to be more branched. *T. steudneri* is widely distributed over the Kenya highlands, mostly in the areas of better rainfall, and occurs at altitudes from 6,000 ft. to over 10,000 ft. usually on swampy ground. This clover has been cultivated on a small scale at the Kitale Grassland Station and found to be more stemmy and less attractive than either *T. rueppellianum* or *T. usambarense*.

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THE MANGOES OF THE KENYA COAST

By Susan M. Wheatley, Department of Agriculture, Kenya

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BOTANY

The Mango, *Mangifera indica* L., is of the Anacardiaceæ family to which the cashew nut belongs. A characteristic of the family is the presence of a caustic sap, and this is obvious in the mango in the immature fruit. The *Mangifera* genus is indigenous to Eastern Asia, and some notes on the origin of *Mangifera indica* are given by Greenway (1944).

The mango tree is a large evergreen. Seedling trees may attain a height of 50 ft. or more, with a similarly large branch span, and may live to over 100 years. The shape of the tree varies according to the growth habit of the variety or seedling race. These habits fall into three groups to give trees that are upright, round or pyriform in shape. Foliage is dense with many simple, entire lanceolate leaves of some 6-18 in. long.

Growth Habits

Several growth flushes a year are experienced by each tree. There are two obvious main growth flushes along the Coast. These occur in May-June following the break of the long rains in April, and a flush occurs again in November-December with the advent of the hotter weather. The whole of a tree does not flush at once so that during growth-flush periods trees are seen with sections of new limp red leaves, further sections with older copper to pale green leaves, while the remainder of the tree may be of dark green leaves where the flush has not commenced yet.

Young trees that have not commenced bearing will flush much more frequently than older bearing trees.

The new leaves are red to orange or red-purple in colour and are very limp. As they grow they turn to copper and then pale green, and finally when elongation is complete to dark green firm leaves. The new growth is said to have "hardened off" at this stage.

Vegetative and Flower Growth Relationship

There is a distinct relationship between vegetative growth and flower growth. Flower bud initiation usually occurs on wood that is a season old. Along the Coast mango trees blossom twice a year, in August-September to

give a crop in December-January, and in February-March to yield the mid-year crop of June-July. These flowering periods are subsequent to the May-June and the November-December growth flushes respectively.

Shoots that produce fruits do not produce new vegetative shoots the same season, although shoots that flower but do not set fruit may produce vegetative growth that season. Thus shoots of the June flush that hold fruit for the December crop will not flush in November, but they are likely to flush again the following June; while those June flush shoots that do not flower that season are likely to flush again in November.

An early heavy flush is often followed by extensive blossoming, and if the resultant fruit-set is good then the subsequent flush will be followed by a poor fruit crop. Individual trees develop a tendency therefore to bearing in alternate seasons.

Individual trees may flush out of season and flower out of season, probably due to the effect of climatic factors on such trees.

The whole relationship between vegetative and flower growth needs more detailed investigation. Local information from the growers is not forthcoming, for their knowledge as to when their trees flush and flower is negligible.

The Flowers

The inflorescences are terminal panicles. Each panicle bears 200 to 4,000 or more small sweet-scented pale yellow to pink flowers. The flowers have a diameter of about $\frac{1}{4}$ in. Two distinct types of flowers are observed, the staminate and the perfect flowers.

The number of staminate or male flowers to a panicle varies according to the variety or type, but 25 per cent to 98 per cent of the flowers may be male. The staminate flower consists of five sepals, five petals, usually only one functional stamen and four staminodes. The bisexual perfect flower is similar to the staminate but has also the gynoecium with a round ovary.

There is evidence that the flowers are insect-pollinated for they produce nectar and are sweet-scented. There is some world controversy however, as to whether they are

insect-pollinated or whether each flower is self-pollinated. Fruits will not mature unless flower pollination has occurred, but fruit setting is not dependent on pollination. Some varieties are prone to setting large crops but with only a few of the fruits possessing fertilised embryos. This "small fruit" abnormality may be due to the climatic conditions at the time of fruit setting, resulting in this physiological condition in certain varieties. The local seedling "Dodo" may be prone to this "small fruit" as many fruits drop before they are fully mature.

Extensive blossoming is not necessarily followed by a large crop. Fruit-setting, and fruit-dropping soon after setting, are affected adversely by strong wind and rainfall at this time. Observations in India have shown that about 10 per cent of the flowers are perfect and of these some 50 per cent are not pollinated and 49 per cent drop after setting. The remaining 0.1 per cent of the total flowers that develop to mature fruits result in an average yield of 200 fruits per tree. Many of the seedling races of the Coast probably conform to this order.

Polyembryony and Monoembryony

Most plants of horticultural interest produce one gametic seedling from one seed, and this seedling has the hereditary characteristics of both parents. The mango is one of the few trees from which nucellar seedlings can be produced. Some of the mango seedling races show polyembryony to a high degree, that is several embryos develop in one seed. There is the usual single sexual embryo, and several further embryos that develop as adventitious buds, and according to Popenoe these are from the nucellus tissue of the seed. These vegetative or nucellar embryos give rise to seedlings that are genetically identical with the parent tree.

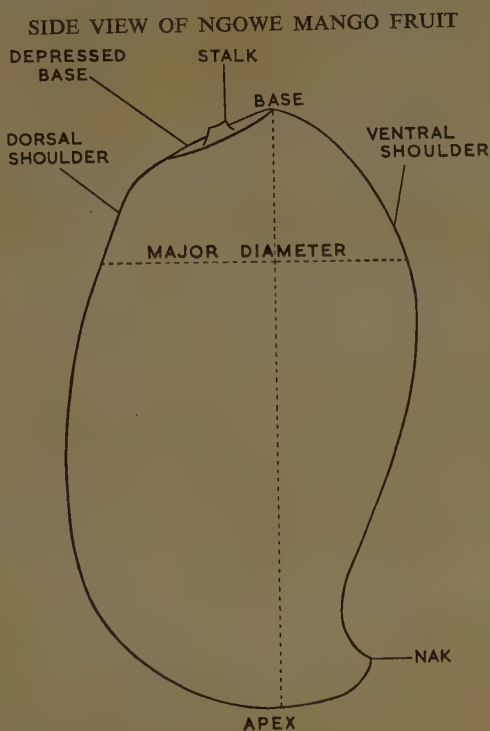
The flowers of polyembryonic trees have to be pollinated if the fruit is to mature. The resultant sexual embryo is suppressed by the growth of the vegetative embryos. When the seed is sown the sexual embryo either fails to germinate or it produces a seedling that is very much poorer than the other seedlings, and so it can be easily recognised. Polyembryonic seeds give rise to one to five seedlings.

Most of the named Indian mango varieties are monoembryonic and so cannot be propagated from seed. The better Coastal seedling races are polyembryonic.

The Fruit

The fruit takes about five months to develop from blossoming until ripe. The shape, size, and skin colour of the fruit, and the colour, texture and flavour of the flesh vary considerably according to the variety or seedling type.

The mango fruit is described with the stigmatic point or "nak" facing to the left or ventral side of the fruit. This nak is situated at varying distances from the apex of the fruit, according to the variety. The left or ventral shoulder develops more than the dorsal shoulder but below the shoulders the ventral side is usually concave and the dorsal side convex. These shoulders and sides give the characteristic mango shape. At the base of the fruit the stalk may be in a depression or it may be raised. The major diameter of the fruit is that distance between the two shoulders, and the minimum diameter is that through the fruit in a line at right angles to the maximum diameter.



The skin colour varies with the variety or race from a pale yellow green to deep red. Flesh texture may range from extremely fibrous flesh to a virtually fibre-free melting flesh, and distinct flavours are characteristic of the different varieties and seedlings.

Classification

The nomenclature of the mango varieties of the world is confusing, since a variety is often known by more than one name. The local seedling races, which are, with a few exceptions, the only mango types of concern along the Coast, are known by local names. The names applied to the more palatable races are standard, but the common trees of poor quality fruits are often known by several local names, according to the district in which they are established.

The following classification is based on the characteristics of the fruit. This limits identification to certain times of the year, but the fruits provide the easiest means of recognition of the so-called varieties. Those familiar with local mango races may recognise the trees by other minute details such as leaf differences.

KEY TO THE CLASSIFICATION OF COASTAL MANGO SEEDLINGS

- | | | |
|---|---|--------------------|
| 1 | Fruit, large | 2 |
| | Fruit, small | 3 |
| 2 | Fruit not long but nearly round .. | 4 |
| | Fruit, long, base to apex measurement obviously longer than major diam. .. | 5 |
| 3 | Fruits with prominent nak | 6 |
| | Fruits with obscure to nearly obscure nak | 7 |
| 4 | Fruit nearly round, nak nearly obscure. Skin olive to olive red when developing, to bright green, and deep yellow-orange flushed with red when ripe. Monoembryonic. | |
| | Fruit nearly round, very large. Prominent nak. Skin red-purple to olive green with thick bloom on developing fruit, and rich olive green to purple maroon mature fruit. Polyembryonic. | <i>Apple mango</i> |
| 5 | Fruit long and slender, prominent nak. | <i>Batawi</i> |
| | Fruit long but not slender to fairly long .. | <i>Ngowe</i> |
| 6 | Fruits with prominent nak, base of fruit nearly opposite nak so orientating nak to face directly downwards. | 8 |
| | Fruits with prominent nak at usual position below concave ventral side .. | <i>Kiarabu</i> |
| 7 | Fruits long and slender, nak obscure. | 9 |
| | Fruits not slender, but long to round .. | <i>Punda</i> |
| 8 | Fruit long, nak obscure, shoulders only slightly curved with nearly flat dorsal side and slightly concave ventral side below shoulder. Fruit pale green with bloom, pale green to yellow when ripe. | 10 |
| | Fruit fairly long, nak obvious and round, shoulders very round, with dorsal side round and ventral side concave below shoulder. Fruit dark green with bloom to green and yellow-orange when ripe. | <i>Boribo</i> |

- | | | |
|----|---|--------------------|
| 9 | Fruits round, fairly large, with prominent downward facing nak. | <i>Kitovu</i> |
| | Fruits that do not conform to any of of above | 12 |
| 10 | Fruits with obscure nak, ventral side not concave, shoulders slightly swollen. Fruit very small-oval, somewhat egg-shaped. | <i>Mayai</i> |
| | Fruits with obscure nak, fairly round in shape | 11 |
| 11 | Fruits, small, fairly round, green with thick bloom in developing to give a dark blue-green colour. Green to yellow with thick bloom when mature. | <i>Kimji</i> |
| | Fruits that do not conform to any of above | 12 |
| 12 | Fruits small, nearly round, with or without obvious nak. | <i>Other races</i> |

Apple Mango.—This is not a polyembryonic race and has only recently been grown from seed taken from the variety. Some of the few seedlings grown locally have produced such good quality fruit that the mango has become well known in Malindi. The apple mango is included, therefore, in this list.

The seedlings from this monoembryonic fruit are heterogenous and there is evidence of this at Malindi where seedlings have commenced bearing. Some of the seedlings have borne inferior quality fruit. The better seedlings have produced fruits round in shape that ripen to a rich yellow-orange to red. The flesh inside is of excellent flavour and of melting texture virtually free from fibre. The local Malindi growers class this as the best of the mango fruits.

The trees are of the pyriform growth habit. Further propagation of the apple mango should be by vegetative means.

Batawi.—The fruit is easily recognisable as it is very large, apparently round and is a rich olive-green to purple-maroon in colour. The tree is relatively small, round in shape, and bears a medium-size crop.

The fruits have a prominent nak situated opposite the stem which is set in a depressed base. The ventral shoulder is very round, and below this is a slightly concave side terminating in the nak. The dorsal side is very rounded from base to apex. The major diameter measurement is about the same as that from base to apex, and so gives the round effect to the fruit.

The internal quality of the fruit is usually good, both in texture, with little fibre, and in

flavour. The flesh is pale orange in colour. This fruit might be classed third to Ngowe and Boribo in quality.

The seeds are predominantly polyembryonic so seed propagation is possible.

Ngowe.—This is the most easily recognised of the mango fruits. It is large, long and slender with a very prominent hook-like nak at the apex of the fruit. The shoulders are slightly curved, the ventral side is long and concave, the dorsal side long and slightly convex. The fruit is a pale green when developing. The ripe fruit is a most attractive yellow to orange colour flushed with orange-red.

Flesh quality is excellent. It is virtually free from fibre and is melting. The colour is a deep yellow, the flavour is delicate and is not of the usual turpentine taste of most mangos.

The fruits travel satisfactorily if harvested at the right time. They always fetch the highest price on the market and can be considered a luxury article.

The tree is comparatively small and is round in shape. Yields are in the region of 200 to 300 fruits a season. The seeds are polyembryonic.

The Ngowe fruit is known as the Lamu mango on the up-country market, and it is exclusively from Lamu that these fruits have come until recent years. Now a few trees at Malindi and elsewhere along the Coast have commenced bearing. The original Ngowe tree still stands at Lamu, and is reputed to have been brought into the country from Zanzibar by the present owner's grandfather about 60 years ago. This tree yields 500 to 600 fruits a season now.

This race is well worth cultivating locally, due to the excellent fruit quality and the small size of the tree. It may well be propagated vegetatively also and established as a horticultural variety.

Kiarabu.—This is essentially a monoembryonic race. Quality is poor. It is grown fairly extensively in the Malindi area but is not common elsewhere. The name may also be applied to other types.

Punda.—This is essentially a monoembryonic race of poor quality. It is not common and a few trees are grown in the Malindi area. The shape of the fruit is somewhat like that of a donkey's ear.

Boribo.—The fruit is large and long but not as slender as Ngowe. It is distinguished

from Dodo externally by its only slightly curved shoulders, nearly flat dorsal side and only slightly concave ventral side below the shoulder. Also the nak is practically absent. The skin is a pale olive green developing to a yellow to green when ripe.

The internal quality is excellent. The flesh is a deep orange-red colour, virtually free from fibre, and of a strong typical mango flavour. The fruit is classed second to Ngowe among the local seedlings, but many Europeans prefer it as it has the typical mango flavour.

The seeds are polyembryonic. The tree is large and is grown extensively in the Malindi area. Many young seedlings have been planted up along the Coast in recent years.

Dodo.—The fruit is large and fairly round, although the base to apex measurement is obviously longer than that of the major diameter. Shoulders are well rounded, with the concave side below the ventral shoulder, and a rounded nak facing downwards.

The skin of the fruit is a dark green with a bloom when developing, and ripens to a dark green to orange colour. The flesh is orange, and fibre content varies from little to much. The flavour is reminiscent of turpentine and is usually strong. The fruit is the best of the more common local races. The seeds are polyembryonic.

The tree is very large and of tall upright growth habit, with dense foliage of small leaves.

Kitovu.—This is a round fruit, green-blue in colour in developing to orange when ripe. Shoulders and sides are rounded, there is no ventral concavity. The nak is very prominent and faces downwards.

This is probably the best of the smaller races in that the flavour is good, but the flesh is very fibrous. The seeds are predominantly polyembryonic. The tree is found extensively only in the Malindi area.

Mayai.—The fruit is small and egg-shaped. The quality is poor. A few trees are found in the Malindi area. The seeds are predominantly monoembryonic.

Kimji.—The fruit is small and fairly round. The nak is usually obscure. The fruit is noticeably blue in colour in developing, due to the presence of a thick bloom over the dark green skin.

The quality of the fruit is poor. There is little flesh and it is extremely fibrous. The seeds are predominantly monoembryonic.

This is the commonest race along the Coast, and old large trees are met frequently. Other local names apply in some districts. The tree is a very heavy bearer, and it is usual for several thousand fruits to develop in a season. It is a recognised local custom that the fruits are free for all. They are of little market value. The tree is tall and upright in growth.

Other Races.—These include a few trees of varying types of little value. Others that cannot be identified from the above may be heterogeneous seedlings from the monoembryonic races. *Zahfrani* and *Kimaji*, which are both variable, fall into this group. *Kiarabu* is sometimes known as *Kimaji*.

CULTURE

Ecology

Many old mango trees are well established in the Coastal belt, and the tree could almost be considered wild. The old large seedling trees seen to-day are probably the result of casting away seeds after eating the fruit, and to distribution of seeds by elephants in the Lamu district, as they are very fond of the fruits. This is particularly so with the local *Kimji*.

The natural growth conditions of the mango are those of tropical regions of fair rainfall, where the tree grows in forest stands of mango. The dense foliage of the trees prevents the growth of other plants, and except for pineapples little can be grown near mango trees. The dense foliage gives relatively cool conditions under the trees. It is noticed that young mango trees grown in isolation are very susceptible to hot winds and sunshine. Natural conditions can be simulated to some extent by laying a thick mulch on the soil of the root area, and by planting trees in areas that are not exposed to high winds.

Soil and Climatic Requirements

The mango will tolerate a fairly wide range of climate, but the tree is essentially a tropical species and is susceptible to frost. A cool winter, a hot summer, little day and night temperature changes and an annual rainfall of 40–60 inches seem to be the ideal conditions. It is important that the weather should be hot and dry at the blossoming and early fruit-growth periods to give the best fruiting conditions. These periods usually occur before the long May rains and the short November rains, but it is well known for blossoming and

fruit setting to coincide with an early break of the rains, with the consequent adverse effect on yields.

Very young trees may need some irrigation during the dry periods if losses are to be avoided. The trees will be better established if water can be applied during the first few years, when the emphasis is on encouraging vegetative growth.

A sandy loam is the ideal soil for the mango, according to authorities in other countries, with a steady water table at 15–40 feet depth. A heavy clay soil and a very light sandy soil should be avoided, although the sands of Lamu, where a high table of fresh water of around 15–16 feet is probably the main factor, supports mango trees satisfactorily. A very rich soil is likely to favour vegetative growth at the expense of flower growth. Poor drainage is not tolerated.

Like all tree crops the mango requires a deep soil and there must be a depth of at least eight feet of suitable soil if seedling trees are to be grown.

Favourable Coast Areas

The established mango trees grow fairly well along the Coastal strip. There is some evidence, however, that certain areas are more favourable than others.

The coral rag is of course unsuitable, due to the shallowness of the soil. The odd pocket of deep soil will support mango trees, but the exposure to hot winds generally renders these pockets undesirable.

Most of the mango trees are grown in the lagoonal sands, and it is in this strip, inland to the coral rag, that the very old seedling trees are found. These sands are generally suitable. The areas that are of poorly drained soils should not be considered. Such areas are usually flooded or water-logged during the rains and any trees that are grown under these conditions are obviously adversely affected. The Freretown limestones of Utange in particular should not be considered for mango cultivation.

The most suitable area is probably the Magarine sands ridge, a range of hills extending along the Coast inland of the lagoonal sands. The altitude of the Magarine sands is in the region of 400 feet and more rainfall is experienced than on the Coastal plain. The south Magarine sands, situated in a higher rainfall area than the north Margarines, are

the more suitable. In fact north of Mavueni, about 35 miles north of Mombasa, the country is too dry for the satisfactory growing of mango trees.

Inland of the Magarine sands the poor soils of impervious shales are met. These are conspicuous by the lack of vegetation and they should be avoided for mango cultivation. These shales are bounded inland on the North Coast by the Kambe limestone series, which appear to support mango trees well. To the south, the Kambe limestones are absent, but there is the Shimba Hills range of some five to twelve hundred feet altitude. It seems that the sandstones and grits of this range could well support mango trees, but those areas that are dominantly shaly should be avoided.

The Mariakani and Duruma sandstones, grits and shales are out of the question, so far as mango-growing is concerned, due to the low rainfall of these inland areas.

Mango cultivation may well be considered at Taveta where adequate water is available for irrigation, but care should be taken not to plant up on the black soils of the forest areas, where heavy irrigation may prove inadvisable.

Propagation

The mango may be propagated by seed or vegetatively by budding or grafting. The local seedling races that are polyembryonic can be produced satisfactorily from seed. Most of the Indian improved varieties are monoembryonic and so must be propagated vegetatively. Some of the Coastal seedling trees give fruits of excellent quality so the vegetative propagation is of little concern except when certain specific named varieties are required.

Seed Propagation

The mango seedling is difficult to transplant and yet the advantages of raising seedlings in the nursery outweigh this one disadvantage. Seedlings should be produced only in propagation nurseries where adequate facilities prevail for such work and where the necessity for strict culling and proper care is appreciated.

Seeds should be acquired from selected parent trees that are known to produce large crops of good quality fruit. The ripe fruit should be opened and the husk of the seed removed as soon as possible after harvesting. This opening of the seed is necessary, as a large proportion of the fruits harbour a developing weevil larva, and this must be

removed before further damage to the embryo occurs. Seeds should be sown immediately after this operation. They will soon lose their viability if permitted to dry out either before or after dehusking. The several embryos to one seed should be left adhering together and care must be taken not to damage these exposed embryos.

Seed-beds should be of a light sandy soil free from stones. The use of an iron sheet some 8 inches below the soil surface to isolate the seed-bed from the lower soil, as is the recommended practice in Queensland, is probably well worth trying. This sheet prevents the development of a long tap root in the seedlings and so encourages a more fibrous root system. The mango seedling does not transplant successfully because of this tap root development. Alternatively, 8-inch seed-beds can be built up over concrete slabs.

The seeds are sown flat, about 4 inches deep in the moist soil, 6 inches apart in the rows and with rows 9 inches apart. A grass mulch can be applied between the rows and a light grass shade should be erected about 4 feet above the seed-bed. Overhead irrigation should be frequent to maintain a moist soil.

The seeds germinate within one or two weeks, and this first flush of growth hardens off about two weeks later. At this stage the shading should be removed gradually until the seedlings can remain fully exposed.

Transplanting of the seedlings into rows is advisable after the first or second growth flush has hardened off, so that the tap root development is retarded. Alternatively the seedlings can be "potted up" into baskets made from woven coconut leaves, and when established these "potted" plants are sent to the growers.

Strict culling is practised at all stages of lifting and transplanting so ensuring that all sexual seedlings and otherwise poor seedlings are rogued out.

Times of Sowing.—It is usual to sow the seeds of the December–January fruit crop, to give seedlings fit for sending out to the growers the following April–May, four months later, when the long rains fall. Unless irrigation is available the seedlings should only be planted out during the long rains.

Vegetative Propagation

The most satisfactory methods of vegetative propagation are budding and inarching. Both these methods should be undertaken in a

nursery. The same care is needed in the raising of these trees as is needed for seedling propagation, and in the first instance the raising is the same; the rootstocks for the budding or inarching are grown from seed. The local Dodo mango is likely to prove a suitable rootstock.

This vegetative propagation work is laborious compared with the production of seedling trees. The details of these methods are not given here as they are unlikely to be practised on any large scale locally in the near future.

Marcottage or air-layering has been attempted locally, but with little success. It has been found that the mango does not produce a good root system from cuttings or layers, so these methods should not be used commercially. *Marcottage* may be resorted to when conditions prevent budding or inarching.

Planting

Mango trees, seedling or grafted, that are despatched bare-root to the grower should transplant satisfactorily providing that:

- (1) the tap-root growth is discouraged in the nursery;
- (2) the trees are not more than 6-9 months old when lifted;
- (3) the trees are not lifted during a growth flush period, but only after the leaves have "hardened off";
- (4) the trees are packed well and are not allowed to dry out during transit;
- (5) correct planting practices are observed.

Lifting the young trees requires care particularly with regard to the root system. Torn root ends should be cut cleanly, and at no time should the roots be left in the sun. The surfaces of the leaves should be reduced by half prior to lifting. The trees will travel well for several days if the roots are puddled in mud and leaves and then tied up well in thick layers of grass.

Planting should follow as soon as the seedlings are removed from the packing. If they are already established in baskets no such urgency is needed.

Planting distances should be at least 40 feet square for most seedling races, although the Ngowe could be planted at 35 feet. The 40 × 40 feet spacing gives 27 trees to the acre. The nature of the mango tree is such that it is best planted in a grove and not with other tree crops. Under local African farming

methods the mango is likely to be grown along with, and at the expense of, cashew nut trees, coconut palms, citrus trees and bananas. Sufficiently wide planting distances cannot be overemphasised when this is the case.

The holes for planting should be prepared in advance of receiving the young trees. The holes should be at least 3 feet wide and 3 feet deep. Some 10 lb. of short cattle manure could be added to the top soil which is then returned to the bottom of the hole when planting. The trees are planted at the same depth in the soil as they were in the nursery. The soil is well firmed down, and finally trees are "watered-in", staked and heavily mulched over a prepared basin area.

Cultivation

Very little experimental work has been carried out on the methods of mango cultivation. Work in progress at Nelspruit, Eastern Transvaal, will provide some information. No such investigation has been undertaken at the Coast.

Intercrops of bananas, pawpaws, cassava, etc., may be grown during the first few years providing that competition with the trees for moisture is avoided. A cover crop should prove beneficial in the early years of the grove and *Dolichos lablab*, or velvet beans, could be tried. Basin areas, 10 × 10 feet in size for young non-bearing trees, should be maintained around each tree and kept free from intercrops, cover crops and weeds, and should be well mulched.

Manuring the trees by the application of cattle manure to the basin area seems to be beneficial during the first four to seven years of the tree life, when vegetative growth should be encouraged. When the tree is bearing, however, nitrogenous manuring may lead to vigorous leaf growth at the expense of the flower growth. Little can be recommended on this subject yet.

Irrigation is definitely beneficial during the first few years, when the trees should be encouraged to grow vigorously. A heavy mulch will help to conserve moisture and so reduce the frequency of irrigations.

Pruning of a mango tree is necessary only in the initial shaping of the tree. The main shoot should be stopped at a height of 3 feet and a framework of branches encouraged at this point to form a head. Lateral shoots below this head should be removed. Otherwise,

apart from the cutting away of dead wood, no pruning is practised, for the mango requires its dense foliage.

Yields

Budded and seedling trees may commence flowering when four years old. Blossom that occurs in earlier years should be removed. Good economic crops may be expected from 9- to 10-year-old trees. An average annual yield of 20-year-old trees of the more palatable local races, is probably 200-300 fruits. No reliable crop records are available, but mature *Boribo* and *Dodo* trees are each reputed to yield 1,000 fruits in a good season.

Pests

Insect pests of local mango trees are generally not serious, although isolated build-ups can cause severe damage to single trees or small groups of trees.

Scale Insects

Coccus sp.—This is often found on mango trees and is the most common causal agent for the growth of the black "sooty mould", a fungus which, growing on the honey-dew excreted by these scales, completely covers the leaves with a thin black web and so reduces the photosynthesis potential of the tree. Control of the scale insects excreting the honey-dew controls the fungus.

This insect is recognised by its pale green or brown colour, oval shape and soft body.

Pulvinaria sp.—This is found commonly in the Malindi area and severe outbreaks have occurred in the district. It is easily identified by the large fluffy white egg-sac behind the small dark brown scale.

Aulacaspis cinnamoni.—This is a large grey-brown scale. It is not common along the Coast.

Control of scale insects can be effected by spraying with Alboleum spray oil at 1 gallon in 40 gallons of water. A second spraying 3-4 weeks later may be carried out if necessary. Very often "spot" treatment only is needed where the scales are restricted to small portions of the trees.

Red Spider Mites (unidentified).—Damage to the tree, when large build-ups occur on the under-surfaces of the leaves, can be considerable. Natural predators will usually suffice to keep down populations, but a 1 in 40 Alboleum spray may be used if insecticidal control becomes necessary.

Gall Fly (unidentified).—Outbreaks of this pest occur seasonally. The new leaves are attacked and the damage caused in some seasons is severe, to the extent of premature dropping of the affected leaves, which may include most of the leaves of the flush so attacked. This pest is highly parasitised by a Chalcid wasp.

Mango Weevil (*Cryptorhynchus mangiferae*).—Up to 90 per cent of the mango crop may be infested by this weevil which attacks the kernels of the seeds. Normally the flesh of the fruit is not affected, however, and this pest is of importance only in so far as it destroys the embryos and prevents germination of the seed.

No control can be recommended yet, although the removing and burning of all fallen fruits and seeds should be practised.

Diseases

Diseases do not obviously affect the mango to any large extent. A fungus disease, *Oidium* sp., attacks the inflorescences, young fruits and small branches, and may account for a considerable reduction in crop size in some seasons. This is probably the worst disease along the Coast.

Further diseases recorded include three species of *Aspergillus*, attacking the young shoots, the *Gleosporium mangiferae* that causes a black spotting of the fruit. There is no accurate information available as to the adverse effect of fruit black spotting, and other agencies may also cause a black spotting of this nature.

Control measures cannot be recommended until further information is available on the local mango diseases.

Harvesting and Marketing

A limited quantity of immature green fruits are harvested annually for chutney. The local market is usually flooded with these fruits twice a year. Most of the mango fruits that are harvested are for the fresh-fruit market in Mombasa and to a limited extent in Nairobi.

The very large tree form of the mango presents harvesting difficulties. It is usual for the trees to be climbed by pickers who pull off the fruit and allow it to drop to catchers on the ground. The fruit is often bruised in this process. Much of the fruit at the ends of the outer branches cannot be reached, and this is permitted to drop off or is pulled off by means of a long hooked pole.

More elaborate means of harvesting that should be used instead of the above local method are:

(1) the use of a long light rod fitted with a hook and bag at the end in such a way that the hook pulls off the fruit into the bag;

(2) the use of a long light ladder which, for ease of handling, could be fitted on wheels;

(3) the use of an elevated platform.

The last is not likely to be used locally for some years, but the rod and the ladder could be encouraged now. The tall nature of some of the seedling races will present difficulties even with these methods, and of the good quality races the growing of the relatively small Ngowe tree should be encouraged for this reason.

Damage to the fruit must be avoided because bruised fruits break down rapidly. Care in handling fruits must be observed at all stages of picking and packing. When harvesting, it is advisable to leave 3-4 inches of the stalk attached to the fruit. If this stalk is broken off next to the fruit a sticky juice is exuded and the fruit is rendered unattractive. The stalk can be cut off about $\frac{1}{4}$ inch from the fruit when packing.

Packing requires as much care as harvesting. Locally the fruits are packed tightly in hand-made baskets, 50-100 fruits to one basket. These baskets are then transported to the Mombasa market by bus or lorry over bad roads. The road journeys may take one to two days and may be followed by rail transport to Nairobi.

The ideal method of packing mangoes is in single-layer wooden trays thinly lined with wood-wool. A tight pack is necessary. Fruits should be graded for size and packed accordingly. Fruit to be transported considerable distances may be harvested five to ten days before they are ripe.

The marketing of mango fruits locally is not satisfactory and badly needs to be organised on a sound basis. A series of middlemen is used, and the better quality fruits are sold on the retail market at a fantastically high price. This price often represents some 300-500 per cent profit over the original grower's price. Each middleman will make 30-100 per cent profit on paper. This is rarely represented as such in his pocket, however, as approximately 30 per cent of the fruit bought by each trans-

actor is lost, due to damage of the fruit by bad handling.

Transport charges, particularly if passenger buses are used, are often high. The grower may accompany his fruit to market by bus, or may sell it to a middleman prior to transporting. Large quantities of fruit are auctioned each season at the Mwembe Tayari "market" in Mombasa. The auctioneer charges about 5 per cent profit. It is usual for the fruits to be unpacked prior to auctioning, and when bought they are thrown into hand-carts. The buyers at this stage may be wholesalers or retailers. The wholesaler usually sells to the Mombasa shopkeepers or stallholders, and in the height of the season to retailers in Nairobi.

The larger growers, particularly those of Malindi, will transport their own fruits and will often sell direct to the wholesaler. Many of the better fruits find their way not to the Mwembe Tayari market but to the fruit stores of more wealthy growers situated in a small cul-de-sac off Salim Road opposite the Mombasa Municipal Market. The fruit may be auctioned here, having been held in the store until it is suitably ripe for selling.

The Ngowe fruits invariably fetch the highest price, with *Boribo* second, but there is not a good market for the poor quality fibrous fruited races. Ngowe fruits may be sold by the Lamu growers at 30 cts. to 35 cts. a fruit and are bought by the consumer at Sh. 1 to Sh. 1/50 each, depending on the availability of fruits on the market.

It is extremely hard to obtain accurate information on the marketing procedure of mangoes. The local people are wary of divulging too much.

Markets for the good quality fresh fruits could be found in Nairobi and other East African towns. There is also the possibility of juice extraction or the canning of local fruits. The overseas fresh fruit market is worth investigating.

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REVIEWS

FLORA OF TROPICAL EAST AFRICA: CONNARACEÆ, published under the authority of the Secretary of State for the Colonies by the Crown Agents for Oversea Governments and Administrations, 4, Millbank, London, S.W. 1; pp. 27 and 9 figs., price Sh. 3.

On 18th April a further part of this important Flora, the Connaraceæ, was made available to the public for the sum of Sh. 3. It is bound in its normal format and contains 27 pages, with nine figures in black-and-white. It was prepared by Mr. J. H. Hemsley, one of the Colonial Office botanists employed on this flora at the Royal Botanic Gardens, Kew. The family is closely related to the Leguminosæ and is restricted to the tropics, being mostly twining shrubs. It contains 24 genera of which nine are represented in our region, with, as delimited by Hemsley, 16 species, one of them, in the Pantropical genus *Connarus*, recorded from the Kwale district of Kenya being imperfectly known.

Keys are provided to the genera and species to enable one to find out the genus and species of any member of this family. There is a full description of the family followed by the key to the genera; then under the genus there is a full generic description followed by a key to the species it contains.

Each species is fully described, the type when known indicated and the geographical distribution of the species throughout East Africa quoted, along with the collectors' names and numbers for those specimens that were examined during the preparation of the Flora. Extensions of geographical range along with the plant's habitat is also shown.

Should this part of the Flora be used by those with only a slight knowledge of botany, they should have no difficulty in finding the genus when using the key to the genera, because each one of the nine genera described is fully illustrated by a black-and-white line drawing. The artists, E. M. Stone and S. Ross-Craig, are to be congratulated on their clear and excellently diagrammatic line drawings.

Of the nine genera, two are monotypic. *Burtia*, named after the late B. D. Burt, botanist to the Tsetse Research Department, Tanganyika, is found from the dry country of the southern parts of the Lake and Central Provinces of Tanganyika and then reappears

in the Abercorn district of Northern Rhodesia. It is a delightful shrub or small tree with white flowers like those of a plum or cherry (hence its specific name *prunoides*), which come out with the young leaves. It is well worth a place in any garden. The other is *Vismianthus punctatus* Mildb., only recorded from the Lindi and Newala districts of the Southern Province of Tanganyika. This shrub is found in coastal evergreen bushland and secondary forest on margins of native cultivation and we would like to know more about it, as ripe fruits and mature seeds of it have yet to be obtained and described. It is related to *Burtia*.

Mr. Hemsley is to be congratulated on his treatment of this family, members of which he saw in the field during his recent collecting trip in East Africa. Specimens of his collecting are quoted in the Flora.

Economically as yet the family Connaraceæ is disappointing; it appears to be of little importance.

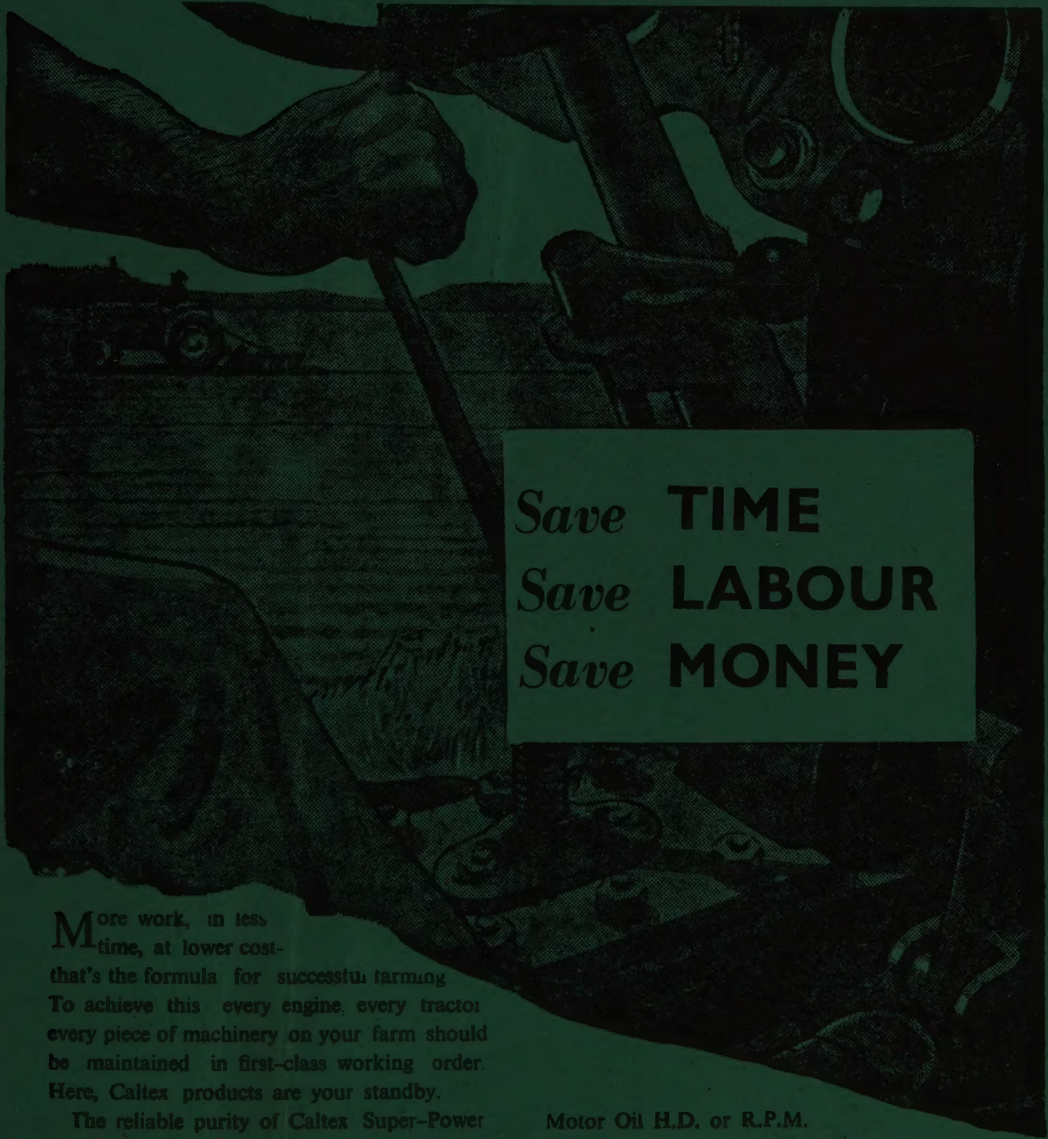
P. J. G.

CULTURES TROPICALES I—PLANTES VIVRIERES par R. Cerighelli, publiée par J. B. Baillié-re et Fils, Paris, 1955, prix 4,800 francs.

This is the first volume of an encyclopædia of tropical crops, and the series of three volumes will be of great value in tropical agriculture, particularly if an English translation is produced later. Volume I deals with food crops; Volume II will deal with tea, coffee, cacao, fruits, spices and medicinal plants; and Volume III will deal with industrial crops such as sugar cane, oil palm, jute, sisal, rubber and groundnuts. In the text the sequence is the same for each crop: (a) history, botany, growth characteristics and ecology; (b) pests and diseases; (c) cultivation; (d) chemical composition and manufacture of crop products.

This first volume of 636 pages contains a wealth of information on rice, sorghum, millet, cassava, sago, arrowroot, sweet potato, yam, taro, breadfruit, christophine, beans and banana. While most of the information is available in books on the individual crops, the standardised format of this book makes reference easy, and it fills a long-felt want in replacing less comprehensive books on tropical crops which were written over 20 years ago.

D. W. D.



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